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PROGRESS IN SOIL AND WATER CONSERVATION RESEARCH

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USE OF THIS REPORT

These Quarterly Reports are prepared by scientists and engineers of the Soil and Water Conservation Research Division. They are reviewed for technical excellence and applicability to soil and water problems and edited by the Branch staffs and SCS-ARS Research Liaison Representatives.

Following each item in the report the specific need to which the item responds is indicated by code. The code consists of the numerical and alphabetical designation of headings in the most recent National Soil and Water Conservation Research Needs Report of SCS to ARS.

This is not a publication and should not be referred to in literature citations. The report is distributed to U. S. Department of Agriculture personnel engaged in soil and water conservation and to directly cooperating professional agricultural workers who are in a position to analyze and interpret the preliminary results and tentative findings of experiments reported herein.

The Division will publish the results of experiments reported here as promptly as possible. Some of the results carried in these Quarterly Reports are simultaneously in the process of publication.

Personnel desiring to make public references to data or statements in this report should submit the proposed material to the Division for approval, indicating the intended use. The Division, but not the report, may be given as the source.

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The Soil and Water Conservation Research Division works in cooperation with State Agricultural Experiment Stations.

Assembled in the office of H. C. Fletcher, ARS-SCS Liaison Officer.

Report for January-June 1960

Issued October 1960

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Alabama

THE DESIGN OF FURROW IRRIGATION SYSTEMS

W. C. Little and F. A. Kummer, Auburn.--A procedure or method for determining the optimum stream size, running time, efficiency and uniformity of application of irrigation water prior to landforming is currently being developed. The procedure is numerical and employs the use of two empirically derived relationships in the form of graphs. They are: (1) Flow rate versus stream width for various slopes and (2) furrow intake rate versus stream width for various time intervals. The basic design criteria for the design procedure are the same as have been previously established in several Soil Conservation Service handbooks.

The design procedure is approached by using short time intervals, since the furrow intake rate changes rapidly with time, and calculating the distance the water will advance during that time interval. Calculations are continued until the cumulative lengths calculated equal the row length. The volume infiltrated for each length is calculated for each time interval until the cumulative infiltration volume is the desired application. The total volume applied less the amount infiltrated and stored on the surface is the volume lost (runoff). The efficiency and running time is then calculated. By choosing several stream sizes and computing the efficiency and running time for each, the optimum stream size is determined by comparing each. (II-A-4)

California

EVAPOTRANSPIRATION INCREASES WITH DISTANCE FROM OCEAN

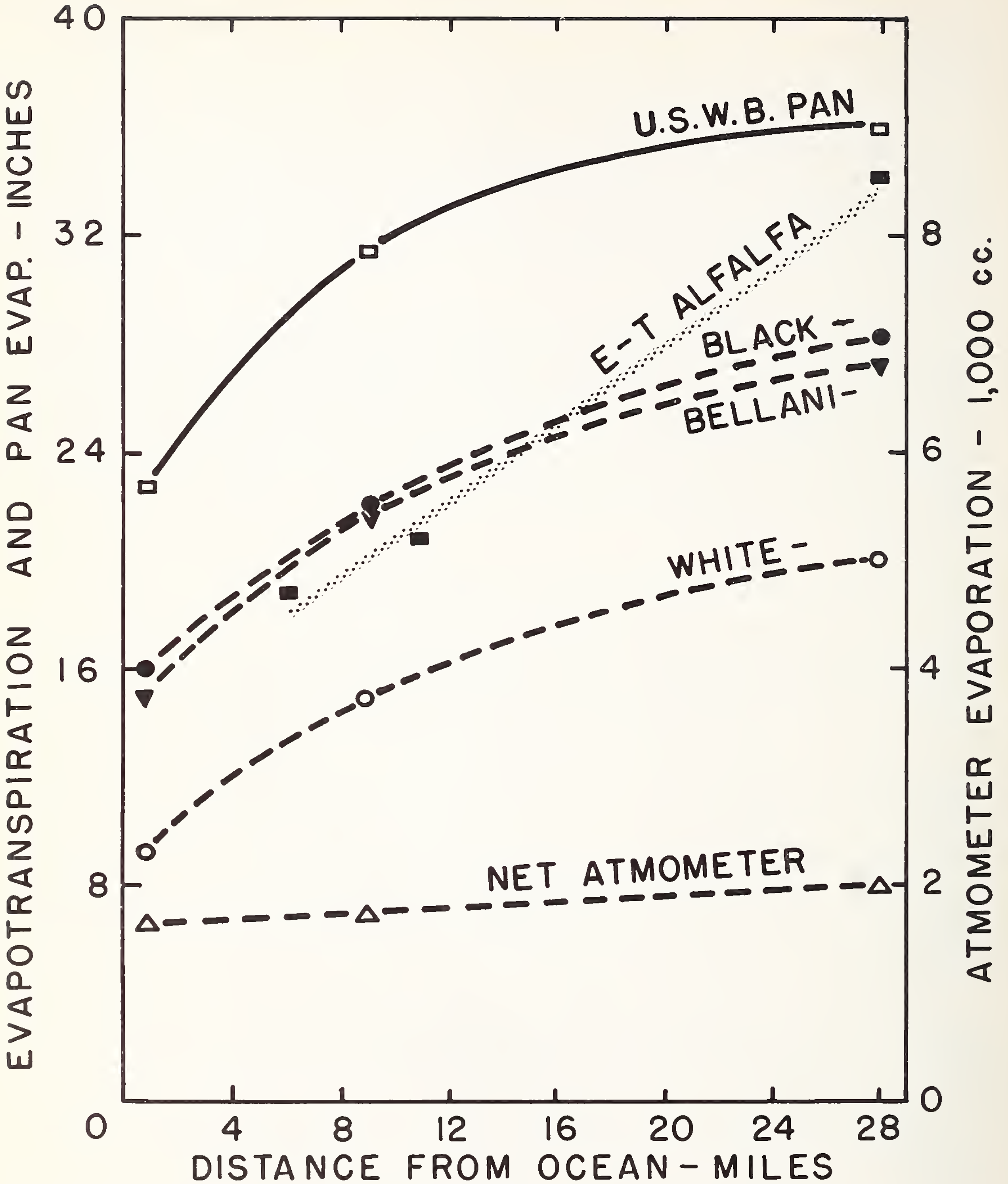
Paul R. Nixon and Ernest J. Wiedmann, Lompoc.--The effect of a climate gradient upon evapotranspiration from irrigated fields is apparent from data collected in the Santa Ynez River Basin, California. Figure 1 illustrates evapotranspiration from alfalfa with respect to distance up the valley from the seacoast, for the period June 1 through September 30, 1959. Also illustrated is evaporation from some climatological devices.

Judging from general observation and from the increase in net (black minus white) atmometer evaporation, there is some increase in solar radiation with distance from the coast. However, this increase in insolation is nowhere in proportion to the increase in evaporation or evapotranspiration. During the period discussed, the mean atmospheric transmission coefficient was 0.71 at the station 9 miles from the coast. (The atmospheric transmission coefficient is the ratio of measured solar radiation on a horizontal surface to the computed solar radiation on a horizontal surface at the top of the atmosphere.) It is unlikely that the mean atmospheric transmission coefficient exceeded 0.80 at the 28-mile station. So it is improbable that radiation at the inland station was as much as 13 percent greater than at the 9-mile station.

A comparison of average temperatures, shown in figure 2, with the evapotranspiration amounts indicates that other factors are also important. Although the differences between average temperatures at the three stations were not great, figure 2 shows that maximum temperatures differed more noticeably.

The lower air humidity associated with the higher daytime temperatures is probably a principal factor. Exploratory studies with data from the 9-mile station have given fairly good correlations between evaporation and a function of solar radiation, temperature, and humidity.

Wind movement was about the same throughout the study area. West-northwesterly wind movement was from the ocean toward the inland. Average wind movement, at 18 inches above the ground, is given in figure 3.



U.S.W.B. PAN
E-T ALFALFA
BLACK
BELLANI
WHITE
NET ATMOMETER
EVAPOTRANSPIRATION AND PAN EVAP. - INCHES
ATMOMETER EVAPORATION - 1,000 cc.
DISTANCE FROM OCEAN - MILES
0
4
8
12
16
20
24
28
32
40
2
6

FIGURE 1

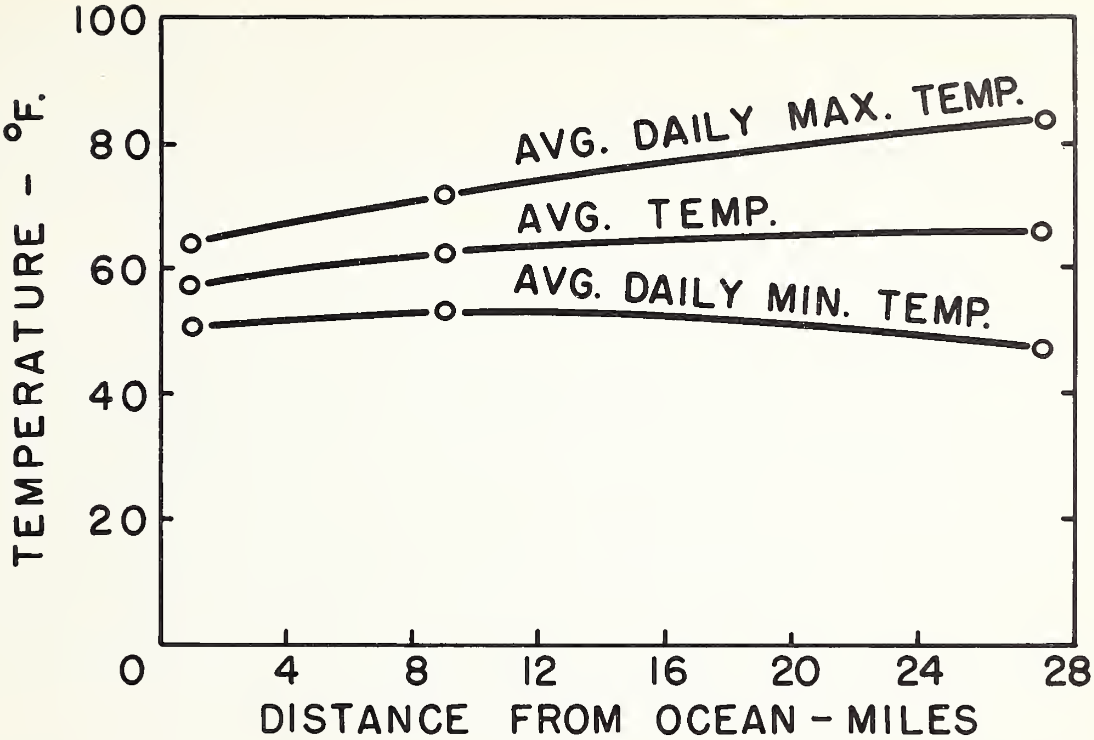


FIGURE 2

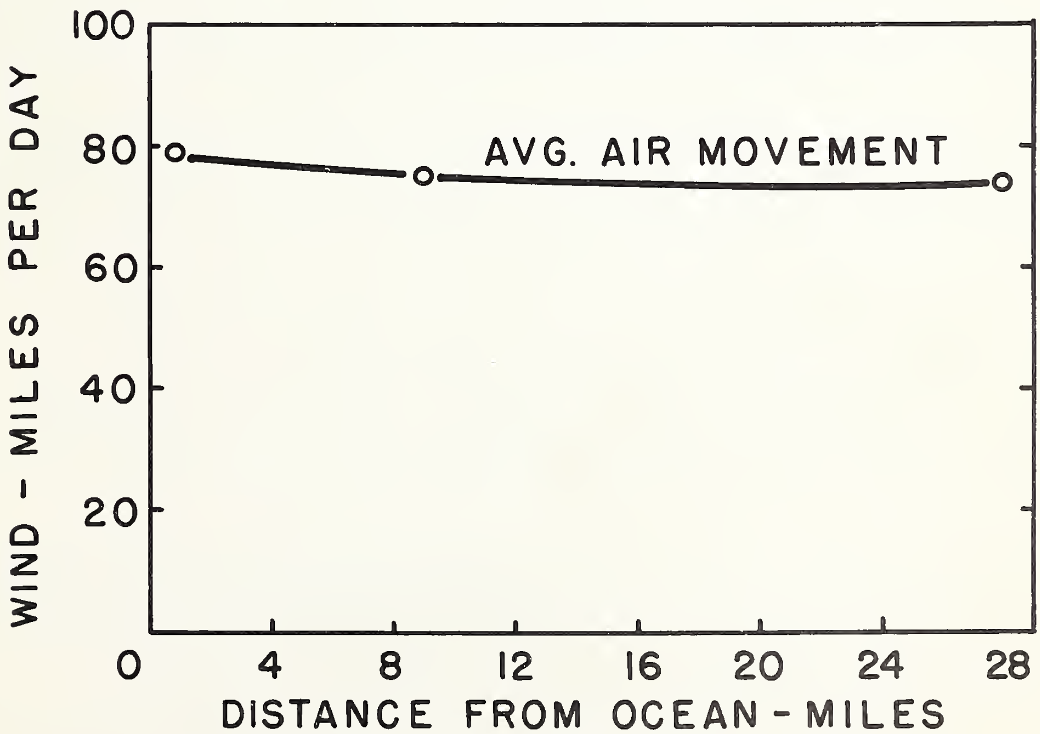


FIGURE 3

Increase in evapotranspiration from sugar beets and beans, with distance from the ocean, was observed in 2 previous years. In these cases, also, the increase of evapotranspiration with distance exceeded the increase of individual climatological factors measured.

This study is being continued in an effort to isolate the governing climatological factors in the evapotranspiration process and in hope of finding simple instruments that will adequately estimate evapotranspiration. (II-A-1)

California

FILTERS IMPROVE PERFORMANCE OF MODEL RECHARGE WELLS

Leonard Schiff, Fresno. --A sand filter improved the performance of model recharge wells. Filtered and unfiltered waters entering wells at the same rate initially occupied about the same depth in the model wells. Subsequently, in wells receiving unfiltered water the water rose appreciably above levels of those in wells receiving filtered water. This was largely due to clogging by suspended solids. Filtering through only a few tenths of a foot of filter material reduced the suspended load from an average of 20 p.p.m. to approximately 1 p.p.m. The infiltration rate for the filters was essentially the same with water flowing over the filter and when water pooled on the filter. Raking the filters over which water flowed to a depth of about one-half inch caused deposited fine material to go into suspension and to be carried away. By this process good recovery occurred in the entry rate of the filters and thus the wells. Velocities used were not great enough to move surface particles of the filter. Such movement may result in self-cleaning action similar to rivers.

The filter material was prepared by screening sand to eliminate particles less than 0.5 mm. This material was placed over perforated drain pipes in flumes. Flumes used were 7 feet long, 1.3 feet deep, and 0.33 foot wide. Drain pipes discharged into the top of model wells. These wells were perforated pipes 0.33 foot in diameter and extended 5 feet into natural aquifer material. In some experiments river water was pooled over the filter material; in others, river water was allowed to flow over the filter material. For further comparison unfiltered river water was injected directly into wells.

This approach envisions the possible use of canals or ditches with shallow wells spaced at reasonably uniform intervals along the bottom. The wells could be backfilled with various materials of high porosity with filter materials on top. To further increase flow into wells drain pipes could be laid along the bottom outletting into the wells. Filter materials would be placed over the drain pipes. (I-B-6)

California

MOISTURE PENETRATION MEASURED BY NEUTRON METER

Curtis E. Johnson, Fresno. --In order to properly evaluate an area for use as a ground water recharge site, the relative ability of the substrata to transmit water down to the water table must be determined. Under certain conditions the neutron moisture meter has proven to be a useful tool for this purpose.

In a recent test using a 2 1/2-acre test plot containing three cased holes for neutron meter measurements it was possible to follow the downward movement of the wetting front from the surface to the water table. At the start of the test the water table in an observation well in the plot was 43 1/2 feet below ground surface. The surface of the test plot was kept continuously flooded for a period of 15 days. Within 5 1/2 days, the wetting front had reached the water table.

At the end of the 15-day flooding the water table had risen 10 1/2 feet. By continuing measurements after water disappeared from the surface the rate of soil moisture drainage was established. The recession of the temporary water mound was also followed. The

difference between the water content of this zone at saturation and after drainage is the specific yield of that zone.

Analysis of the water content of various soil layers before flooding and during flooding showed a zone of high water content was produced down to 20 feet. This indicated a restricting layer at the 20-foot depth. In future test runs on this plot piezometers will be installed in this zone to determine if saturation actually occurred. (I-B-6)

California

RESEARCH EXPANDED TO MEET GROUND WATER RECHARGE NEEDS

Leonard Schiff, C. B. Johnson, W. C. Bianchi, and K. L. Dyer, Fresno.--An expanded and reoriented project in ground water recharge research has been established at Fresno in cooperation with the California Department of Water Resources and the California Agricultural Experiment Station. Preliminary studies by the Department of Water Resources show a need for over 10 million acre-feet of artificial recharged water annually in the Central Valley of California. Artificial recharge is also needed in other areas of California.

Previous work at Bakersfield stressed the development of soil and water treatments, operational procedures that increase infiltration and percolation rates, and methods of alleviating or reducing clogging to maintain rates.

The reoriented program initially emphasizes the development of information on the relationships of site characteristics: (1) To recharge potential, (2) to the feasibility of incidental recharge by overirrigation of crops (which may best be called recharge irrigation), and (3) to characteristics of the recharge water and to the resulting quality of ground water.

Six experimental plots are being set up for study, two on the west side and four on the east side of the San Joaquin Valley. The plots vary from about 80 to 120 feet in width and are 1,320 feet or so in length as governed by the normal irrigation run for the location. The surface soil on each plot is reasonably representative of a large area, and the plots cover a wide range in soil characteristics. Five of the six plots will provide information on the irrigation approach to recharge. The problems of maintaining a high level of crop production while providing maximum deep penetration of water to build up water storage must be met simultaneously. Leaching of nitrates and water logging of soils are examples of the kind of problems involved in maintaining crop production under this regime.

Soil samples have been obtained on all plots from all increments of depth to 50 feet. Below 50 feet samples were taken at depths reflecting strata change with intervals not exceeding 10 feet to the water table or a soil layer that will perch water (50 to 120 feet). However, on the two plots on the west side soil samples were taken to a depth of 230 feet. Laboratory facilities and procedures are practically completed for processing and analyzing the samples for physical and chemical properties. Chemical analysis will include the determination of calcium, magnesium, sodium, potassium, boron, chloride, sulfate, bicarbonate, nitrate, gypsum, calcium plus magnesium, carbonates, cation exchange capacity, and exchangeable sodium and potassium.

Four access tubes were installed by air drilling on all plots down to the water table to permit measurements of moisture changes with the neutron moisture meter and observations of the development and recession of water table mounds. Three of the access tubes are close together at the one-third point (one-third length of irrigation run) and the fourth is at the two-thirds point. The drill crew and well drilling equipment were provided by the California State Department of Water Resources. The moisture flow along the vertical gradient will also be estimated from the conversion of field moisture data into permeabilities and moisture tensions as determined from laboratory analysis of field cores.

Initial soil moisture measurements have been made of the soil and substrata. A tube with about 20 feet perforated at the lower end has been installed near the one-third point on each plot. Samples of water taken from this tube as the mound develops will be analyzed for quality. Information is sought on quality changes in the recharge water as it percolates downward and on the effect of this water on the ground water quality. Piezometers are now being installed at strategic locations and depths on plots.

Plots are located on the Huron and Cantua Farms of the Anderson Clayton Company and on farms in the Lower Tule River Irrigation District Area. The cooperation of farmers, managers and members of the company and district involved is very helpful to the development of information on this method of storing water for cyclic use. (I-B-6)

Colorado

DESIGN AND CALIBRATION OF TRAPEZOIDAL MEASURING FLUMES

A. R. Robinson, Fort Collins. --Several types and sizes of trapezoidal measuring flumes have been studied and calibrated. These range in size from a small V-notch flume, intended primarily for furrow measurement, to one designed for streams with flows up to 400 c. f. s. Most of these flumes have also been studied and calibrated under submerged conditions.

Trapezoidal flumes or flumes with sloping sidewalls in contrast to the rectangular types have certain advantages. These are:

1. Approach conditions seemed to have a minor effect on the head-discharge relationships.

2. Material deposited in the approach section of the flumes did not change materially the relationships.

3. A large range of flows can be measured through the structures with a comparatively small change in head. Very small flows can be measured with the same range of accuracy as large ones due to the trapezoidal shape.

4. The flumes will operate under greater submergence than rectangular ones of comparable capacity without corrections being necessary to determine the correct discharge.

5. The trapezoidal shape fits the common canal section more closely than a rectangular one. Scour problems should be less with this trapezoidal shape.

6. Construction details such as transitions and form work are simplified. (II-A)

Colorado

DESIGN CRITERIA DEVELOPED FOR VORTEX TUBE SAND TRAP

A. R. Robinson, Fort Collins. --Recent studies combined with other investigations have provided design criteria for vortex tube sand traps. This device is used for removal of bedload from irrigation canals. The sand trap consists of a tube with an opening along the top that is placed in the bed of a canal at an angle to direction of flow. As the canal flow passes over the opening, a spiral motion or vortex is induced within the tube. Material traveling along the bed of the canal is drawn or drops into the tube and then carried to an outlet where it is discharged into a return channel. Usually the vortex tube will be installed near the canal headworks so that removed material is returned directly to the river.

For successful operation of the tube, the following conditions are necessary:

1. The velocity and depth of flow across the section containing the tube should be such that the Froude number approximates 0.8. ($F_r = V/\sqrt{gd}$ where V is the average velocity, g the gravity constant, and d the depth of flow.)

2. The area of tube required can be approximated by the relationship $A_T = 0.06\ DL \sin \theta$ where D is the width of opening, L is the length, and θ is the angle of the tube with respect to the direction of flow. The tube can be a pipe with a portion of the circumference removed to form the opening.

3. The width of tube opening D should be from 0.5 to 1.0 foot.

4. The ratio of L/D should not exceed 20 with the maximum length (L) being approximately 15 feet.

5. The angle θ should be 45 degrees.

With the foregoing design specifications the tube can be expected to remove about 80 percent of sediment greater than 0.50 mm. in diameter. Lower percentages for smaller sizes will be removed. Almost all of the material greater than 1 mm. will be ejected. The amount of flow which will be removed by the operation of the tube will vary from 5 to 15 percent of the total, depending on tube design and depth, and velocity across the section. A channel or pipe with sufficient gradient to convey the removed flow and material back to a natural channel must be provided.

A detailed report giving the results of the study will be available at an early date. (II-D)

Colorado

ORIFICE PLATES FOR FURROW FLOW MEASUREMENTS

A. R. Robinson, Fort Collins.--At the request of the Soil Conservation Service, orifice plates to be used for measurement of furrow flows were studied. Standard rating tables were developed for both submerged and free-flow conditions with the limits for measurement of each type of flow being defined. The effects of upstream approach conditions on the calibrations of the plates were studied and found to exert a minor effect. Also, there was no discernible effect when the plate was set at angles up to 15 degrees from perpendicular to the direction of flow.

Complete calibration tables as well as instructions for use of orifices ranging in size from 3/4 to 4 inches have been developed. (II-A)

Georgia

UNSOLVED PROBLEMS MAKE PEANUT IRRIGATION QUESTIONABLE

G. N. Sparrow and J. R. Stansell, Tifton.--Research into the irrigation of peanuts on Tifton loamy sand in the Middle Coastal Plain of Georgia indicates that there are damaging influences associated with irrigating peanuts. Those factors must be investigated and controls determined before the practice of irrigating peanuts can be recommended generally in the Southeast.

A high percentage of the total peanut crop from irrigated plots in 1959 was left in the soil largely because of weak peg attachment of the nut to the plant. Soil was screened from randomly chosen sample areas of adequate size and to sufficient depth to assure complete recovery of all peanuts left in the sample area after harvest. The table of harvest data points out the highly significant effect of the irrigation on losses of peanuts at harvest.

Peanut harvest and loss recovery per acre from irrigation plots, Tifton Loamy Sand, Tifton, Ga., 1959

Variety	Treatment	Nuts harvested	Nuts recovered from soil	Total yield	Total crop lost in soil
		Pounds	*Pounds*	*Pounds*	*Percent*
Southeastern Runner 56-15........	No Irrigation	2,518	283	2,801	10.1
	Irrigated	1,776	1,056	2,832	37.3
Virginia Bunch 67...	No irrigation	2,729	484	3,213	15.0
	Irrigated	2,174	1,348	3,522	38.3
Virginia Bunch G-2..	No irrigation	2,797	530	3,327	15.9
	Irrigated	1,877	1,793	3,670	48.9

The data indicate a need for caution in recommending irrigation of peanuts generally to farmers. Certainly research must look into the factors indicated as having contributed to the losses of peanuts under irrigation.

The high losses from the irrigated peanuts are tentatively attributed to a buildup of fungi and nematode infestation in favorable moisture environment maintained by irrigation. A high incidence of white mold, Sclerotium rolfsii, was observed on the irrigated plots. Nematode counts made on samples of peanut hulls immediately after digging indicated a heavy infestation of lesion nematodes in irrigated plots. The counts from the irrigated plots were extremely high and were about double those from the nonirrigated plots.

Research into the irrigation of peanuts has been in progress from 1956 with the research having been moved to a new plot area in 1959. Favorable results were obtained from irrigation in 1956 only, which was a year when rainfall was poorly distributed during fruiting of peanuts. (II-A-5)

Idaho

MECHANIZATION OF SURFACE IRRIGATION STUDY STARTED

James A. Bondurant and Allan S. Humpherys, Boise.--A study has been initiated to develop, test, and evaluate mechanized structures and controls for surface irrigation. Mechanical gates and other devices for the automatic control of surface irrigation water, using open ditches or pipelines, will be developed. These will be used to terminate irrigation in one border or set of furrows when the soil moisture is replenished and to start irrigation in the next border or set of furrows. A completely mechanized surface irrigation system is envisioned as one which would receive water from a canal or well, properly irrigate the field portion by portion or border by border, then shut off the water supply and reset itself so as to be prepared for the next irrigation.

Water control mechanisms will be developed and built in the laboratory. These controls will be further tested and their performance evaluated under field conditions. The field tests will be conducted on level and graded borders on an experimental area in the Black Canyon Irrigation District near Caldwell, Idaho. Improvements in irrigation efficiency and water savings will be determined.

Water can be applied to the field with a mechanized, irrigation system with a minimum of labor and when properly designed should provide maximum irrigation efficiency. Therefore, both water and labor can be conserved and better utilized by such a system. (II-A)

Idaho and Utah

CROSS-SECTION AREA DETERMINED FOR LAY-FLAT TUBING

Allan S. Humpherys and C. W. Lauritzen, Boise and Logan.--The shape and cross-sectional area of lay-flat tubing are dependent upon the fluid pressure inside the tube. Since the flow capacity and friction loss for flow through a tube are a function of the tube geometry, tests were conducted to obtain information from which the tube-shape characteristics could be determined. Tests were made on nylon supported, polyvinyl chloride tubes of different diameters. The tubing cross section at various hydrostatic pressure heads was traced with a special pantograph arrangement made for that purpose. The area of the tracings was related to the hydrostatic head, tube height, and height-width ratio.

Using this information, the cross-section area was computed for tubing 4 to 16 inches in diameter at different degrees of roundness and is presented in the table. (II-D)

Cross-Section area of lay-flat tubing of different diameters at different degrees of roundness.

Height-width ratio d/w	Area[1] ratio a/A	Head-diameter ratio H/D	Height-diameter ratio d/D	Tube area (square feet)						
				Tube-Size (inside diameter - inches)						
				4	6	8	10	12	14	16
1.000	1.000	--	1.000	0.0873	0.1963	0.3491	0.5454	0.7854	1.069	1.396
.975	.999	10.90	.985	.0872	.1962	.3487	.5449	.7846	1.068	1.395
.950	.998	8.30	.968	.0871	.1960	.3484	.5443	.7838	1.067	1.393
.925	.996	5.80	.953	.0869	.1956	.3477	.5432	.7822	1.065	1.391
.900	.994	4.35	.936	.0867	.1952	.3470	.5421	.7807	1.063	1.388
.850	.986	2.90	.902	.0860	.1936	.3442	.5378	.7744	1.054	1.377
.800	.976	2.14	.867	.0852	.1916	.3407	.5323	.7666	1.043	1.363
.750	.962	1.70	.829	.0840	.1889	.3358	.5247	.7556	1.028	1.343
.700	.942	1.40	.790	.0822	.1850	.3288	.5138	.7398	1.007	1.315
.650	.921	1.17	.750	.0804	.1808	.3215	.5023	.7234	.985	1.286
.600	.895	1.01	.709	.0781	.1757	.3124	.4881	.7029	.957	1.250
.550	.865	.88	.666	.0755	.1698	.3019	.4718	.6794	.925	1.208
.500	.829	.77	.619	.0723	.1628	.2894	.4521	.6511	.886	1.157
.450	.787	.67	.571	.0687	.1545	.2747	.4292	.6181	.841	1.099
.400	.742	.59	.520	.0648	.1457	.2590	.4047	.5828	.793	1.036
.350	.686	.52	.467	.0589	.1347	.2395	.3742	.5388	.733	.958
.300	.624	.45	.409	.0544	.1225	.2178	.3403	.4901	.667	.871
.250	.552	.37	.349	.0482	.1084	.1927	.3011	.4335	.590	.771
.200	.472	.29	.287	.0412	.0927	.1648	.2574	.3707	.505	.659
.150	.382	.22	.219	.0333	.0750	.1333	.2083	.3000	.408	.533
.100	.275	.15	.150	.0240	.0540	.0960	.1500	.2160	.294	.384
.050	.150	.08	.076	.0131	.0294	.0524	.0818	.1178	.160	.209
.000	.000	.00	.000	.0000	.0000	.0000	.0000	.0000	.000	.000

[1] Ratio of the area of tube at various degrees of roundness (a) to the full round area (A).

Missouri

ROUGHNESS COEFFICIENT OF IRRIGATION FURROWS DETERMINED

J. F. Thornton, Columbia.--The influence of furrow shape and stream size on roughness coefficient was determined on Sharon silt loam in an irrigation experiment at Elsberry, Mo. The data on coefficient of roughness are shown in the table. The "n" was determined after 5 hours of running water down the furrow at which time the intake rate was constant at 0.20 inch per hour. The "n" is the roughness coefficient determined by Manning's formula.

Characteristics of the stream flow in furrows at Elsberry, Mo., 1959

	Flow	Depth	Mean velocity	Froude number	Manning's
	C.f.s.	*Ft.*	*Ft./Sec.*	$F = v/\sqrt{gd}$	"*n*"
S_1	0.053	0.15	0.663	3.00	0.021
S_1	.024	.10	.448	2.51	.029
S_1	.013	.05	.304	2.40	.035
S_2	.024	.15	.421	1.91	.026
S_2	.013	.10	.335	1.87	.029

S_1 - Irrigation shape furrow (20-inch flat bottom 1.5:1 side slope)
S_2 - Conventional shape furrow.

The value of "n" varied from 0.021 for a stream size of 0.053 c.f.s. to .035 for a stream size of 0.013 c.f.s. The size of the furrow stream affects both the mean velocity and "n". The larger the stream size the higher the velocity and the lower the "n" value.

The shape of the furrow affected the value of "n", however, to a lesser degree than did stream size.

The Froude flow criterion varies widely, depending upon the location of the depth measurement. It is, however, very difficult to secure field data on depths and velocity in flow in furrows. At Columbia, emphasis will be placed on securing additional data from models. (II-A-4)

Nevada

INFLUENCE OF WATER TABLE ON WATER USE AND ALFALFA YIELD

Rhys Tovey, Reno.--One season's data from a lysimeter study show that the consumptive use of alfalfa grown under constant water table conditions were considerably higher and the yields slightly greater than that grown in well-drained lysimeters. The experimental variables of the study are: constant water tables at 2-, 4-, and 8-foot depths; some well-drained lysimeters; three soil textures--clay loam, loam, and sandy loam; and irrigated and nonirrigated treatments. The lysimeters are surrounded by alfalfa to simulate growing conditions comparable to those encountered under field conditions.

The data in the accompanying table indicate that the average total consumptive use and yield for nonirrigated treatments decreased as the depth to water table increased. For the constant water table treatments, the nonirrigated lysimeters show a slightly lower consumptive use and yield than the irrigated lysimeters.

Summary of consumptive use and production of alfalfa with varying water table depths at Reno, Nevada, 1959

Water table depth	Soil texture											
	Coarse				Medium				Fine			
	Non irrigated		Irrigated		Non irrigated		Irrigated		Non irrigated		Irrigated	
SEASONAL AND DAILY CONSUMPTIVE USE												
Feet	*In.*	*In/day*	*In.*	*In/day*	*In.*	*In/day*	*In.*	*In/day*	*In.*	*In/day*	*In.*	*In/day*
2................	42.5	0.33	46.8	0.37	47.7	0.37	43.5	0.34	39.3	0.31	41.5	0.32
4................	37.0	0.29	38.3	0.30	45.3	0.35	41.8	0.33	41.5	0.32	36.6	0.29
8................	34.3	0.27	45.6	0.36	36.6	0.29	40.8	0.32	36.1	0.28	43.0	0.34
None[1]...........	--	--	33.9	0.26	--	--	32.7	0.25	--	--	32.1	0.25
YIELD PER ACRE												
	Tons		*Tons*		*Tons*		*Tons*		*Tons*		*Tons*	
2................	8.56		9.05		9.89		8.47		8.59		9.17	
4................	8.51		8.66		9.40		9.74		8.15		7.92	
8................	7.64		9.30		8.67		9.49		8.33		8.53	
None[1]...........	--		7.64		--		9.25		--		7.39	

[1] No water table - drained.

The water table of the area surrounding the lysimeters remained comparatively constant during the growing season and the cover crop yield (8.33 tons per acre) compared favorably with average yield for all of the lysimeters (8.68 tons per acre). The lysimeter alfalfa yields compared favorably with those of other plots and, as expected, were somewhat higher than actual field yields for this area. (II-A-1)

Nevada

VISCOSITY OF BENTONITE SUSPENSIONS MAY CHANGE AFTER HEATING

M. B. Rollins, Reno.--A study on viscosity was undertaken to provide further insight on the sealing action of the bentonite dispersion method of sealing irrigation conveyance channels. Since heating is sometimes used to dry bentonites during processing, the experiment was designed to determine the resulting change, if any, on viscosity of suspensions in which the bentonites had been heated to various temperatures before dispersing.

The study included two Nevada bentonites and one Wyoming bentonite. Samples of these bentonites were heated to temperatures of 54°, 107°, and 160° C., then compared to nonheated samples as the check.

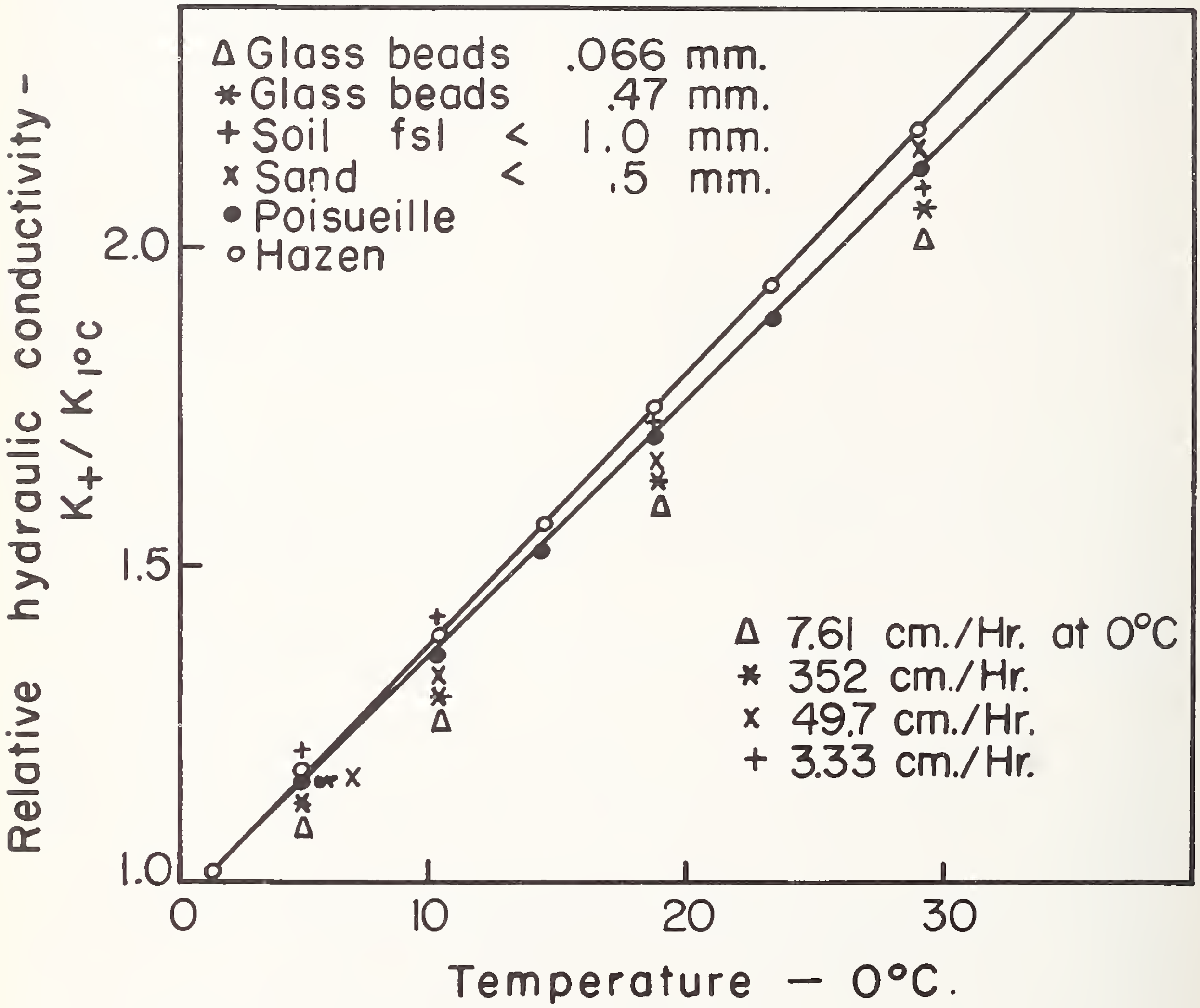
The viscosity varied inversely with the temperature for the Wyoming and the better quality Nevada bentonite. These two bentonites had very high viscosities. The second Nevada bentonite had a very low viscosity, and viscosity changes after heating were not large enough to be considered significant.

Heating some bentonites may provide another avenue whereby the bentonite dispersion method of sealing irrigation canals can be more effectively controlled. Model infiltration studies will be used to explore this possibility. (II-D-2)

TEMPERATURE AFFECTS HYDRAULIC CONDUCTIVITY

W. O. Willis, Mandan.--There are data in the literature which show an inverse relation between seepage flow from canals and soil temperature. This is not in keeping with ordinary concepts. Therefore, a short study was made to determine the effect of temperature on hydraulic conductivity of porous materials when contained in 3-inch cylinders.

The materials used and results obtained are shown in the illustration below.



Effect of temperature on hydraulic conductivity

The smooth curve is from work performed by Poisueille in 1846 using tubes of very small diameter. The equation of this curve is $K_t = K_o\ (1 + .033679\ t + .000221\ t^2)$ where K_t is permeability at some temperature, t^o C., and K_o is permeability at 0^o C. This equation is also a description of reciprocal viscosity. The equation for the straight line is $K_t = K_o\ (t^o\ F. + 10^o\ F.)/60$ where K_t is permeability at some temperature, t^o F. and K_o is permeability at 32^o F. This equation, which corrects K to permeability at 60^o F., is from work performed in 1900 by Hazen using capillary tubes filled with sand.

From the results it appears reasonable to use the equation of either Poisueille or Hazen to correct for temperature effects on hydraulic conductivity. The data in the figure appear to show a slight decrease in relative flow with increased temperature. This may be due to minor biological activity although phenol was added as an inhibitor. (II-A-3)

Texas

DOUBLE-CROPPING IRRIGATED LAND CAN REDUCE EVAPORATION

Marvin E. Jensen and Willis H. Sletten, Bushland.--Growing a summer and winter crop on the same land during the year may reduce annual evapotranspiration from 30 to 40 percent when compared with growing each crop on separate tracts of land with a fallow or noncropping period for each crop during the year. More effective use is made of rainfall received during the fallow period if the area is cropped because very little rainfall is stored on Pullman soil during fallow periods. Rate of water loss by evaporation during the fallow period with a preplanting irrigation just prior to seeding was approximately one-half the rate of evapotranspiration for a crop grown during the same period. These results were obtained from irrigation experiments with winter wheat and grain sorghum at Bushland, Tex.

In these experiments all moisture treatments were in level basins that received a preplanting irrigation 2 to 3 weeks before seeding. The low-moisture level received only the preplanting irrigation, while the high-moisture level was irrigated to maintain near optimum soil moisture conditions throughout the cropping season.

The data in the table show very little difference in the gain of soil moisture during the fallow period between the low-moisture level and a high-moisture level. The soil on the low-moisture level plots was drier at harvest than on the high moisture level plots. The evaporation rate for the fallow period, June-October, averaged 0.079 inch per day, while a growing sorghum crop used water at an average rate of 0.134 inch per day on the low-moisture level plots. On the high-moisture level plots, evaporation during this fallow period averaged 0.073 inch per day, while grain sorghum used an average of 0.206 inch per day.

For the October-June fallow period an average of 0.042 inch per day was lost on the low moisture level plots, while winter wheat used an average of 0.072 inch per day. The average evaporation rate during this fallow period was 0.050 inch per day on the high-moisture level plots, while winter wheat used an average of 0.105 inch per day.

During two cropping and fallow periods winter wheat used an average of 27.06 inches during the October-June cropping period on the high-moisture level. An additional 7.98 inches were lost during the June-October fallow period for a total of 35.04 inches for the year. Grain sorghum used an average of 21.07 inches during the June-October cropping period, and an additional 12.64 inches were lost during the October-June fallow period for a total of 33.71 inches for the year. Therefore, 68.75 acre-inches of water were required annually to grow an acre of winter wheat and an acre of grain sorghum on separate tracts of land. By growing both crops on the same tract of land only 48.13 acre-inches of water would have been required for an acre of grain sorghum and an acre of winter wheat. With an average rainfall of 20 inches per year, a net irrigation requirement of 28 acre-inches would be needed to maintain optimum soil moisture for an acre of winter wheat and grain sorghum when double-cropped. The same irrigation requirement would be needed when growing the crops on separate tracts of land. However, more effective use would be made of the rainfall that falls on an acre of land when double-cropped, and in addition a nonirrigated crop could be grown on the unused area to utilize the rainfall. (II-A-1)

Average evaporation and evapotranspiration losses during two fallow and cropping seasons on low-and high-moisture treatments, Bushland, Tex., June 1956-58

Moisture level	Irrigated winter wheat			Irrigated grain sorghum		
	Fallow June-Oct.	Cropping Oct.-June	Full Year June-June	Fallow Oct.-June	Cropping June-Oct.	Full Year Oct.-Oct.
LOW	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Irrigation.................	7.25	0.00	7.25	5.25	0.00	5.25
Rainfall...................	6.50	12.00	18.50	12.35	9.28	21.63
Total....................	13.75	12.00	25.75	17.60	9.28	26.88
Soil moisture gain.........	5.25	--	--	6.05	--	1.33
Soil moisture depletion....	--	6.35	1.10	--	4.72	--
Evaporation................	8.50	--	--	11.55	--	--
Evapotranspiration.........	--	18.35	26.85	--	14.00	25.55
Rate of loss Inches per day	0.079	0.072	0.074	0.042	0.134	0.070
HIGH[1]						
Irrigation.................	6.75	9.50	16.25	5.25	8.00	13.25
Rainfall...................	6.50	12.00	18.50	12.00	9.47	21.47
Total....................	13.25	21.50	34.75	17.25	17.47	34.72
Soil moisture gain.........	5.27	--	--	4.61	--	1.01
Soil moisture depletion....	--	5.56	0.29	--	3.60	--
Evaporation................	7.98	--	--	12.64	--	--
Evapotranspiration.........	--	27.06	35.04	--	21.07	33.71
Rate of loss Inches per day	0.073	0.105	0.095	0.050	0.206	0.092

[1] Small drainage losses may have occurred during irrigation.

DRAINAGE

Texas

FIELD STUDY OF TILE DRAIN FILTER MATERIAL INITIATED

L. Roy Ussery, Weslaco.--A study to compare the performance of tile drains with three different filter conditions has been initiated in cooperation with the Soil Conservation Service in the Lower Rio Grande Valley of Texas.

Filter conditions being compared are as follows:

1. Graded sand envelope 3 inches in thickness, completely enclosing the line.

2. Fiberglass mat material, Johns-Manville "Tile Guard," forming a complete wrap of the tile.

3. Tile line backfilled with base material excavated from the trench.

Three 6-inch concrete drain lines, 1,200 feet in length, have been laid parallel, 200 feet apart, in similar soil conditions at a depth of 6.5 feet below the ground surface. The gradient on each line is 0.05 feet per hundred feet, the same as the land surface which is

irrigated in the direction of tile-drain flow. The site of this study is in typical Hidalgo clay loam soil which increases in clay content with depth in the soil profile. The particle size distribution in the 6- to 7-foot depth in which each tile drain in installed was very similar.

Average particle size distribution of Hidalgo clay loam soil 6 to 7 feet below ground surface are shown below:

	Particle size (mm.)						
	0.5	0.25	0.20	0.10	0.05	0.02	0.002
Percent finer by weight	99.8	97.1	90.9	83.0	72.2	61.8	46.0

It is not common in the Lower Rio Grande Valley to install tile drain filter material, therefore, none of the local trenching and tile laying equipment is adapted to the installation of filters. The sand filter was installed by hand, using a portable shoring box for covering the tile line. The tile was laid on a 3-inch bed of the sand in the bottom of the trench.

Screen analysis of the sand filter material, as selected by the Soil Conservation Service, is as follows:

	Screen size (Mesh)							
	3/8	10	18	35	60	80	140	300
Percent Passing	74.0	60.3	54.1	38.8	22.3	12.8	1.0	0.3

The sand filter was installed at a cost to the farmer of 20 cents per foot. This includes 16 cents for materials and 4 cents for labor. The high cost of materials is caused by the lack of a local source of sand.

The fiberglass filters were constructed using two rolls of fiberglass matting, 16 inches in width. The bottom of the trench was first formed to the shape of the lower half of the tile, then one layer of fiberglass matting was unrolled ahead of laying of the concrete tile. The second mat was then laid over the top of the tile, overlapping the layer underneath to form a complete wrap of the line. The line was backfilled with base materials by hand to a depth of approximately 3 inches above the tile immediately after laying of the second layer of fiberglass to hold it in place around the line. Other than that normally required for hand installation of tile drain no additional labor was required when the fiberglass material was included. The material used was furnished in 1,200-foot rolls, 20 inches in diameter, and weighing approximately 15 pounds. The cost of the fiberglass material was 4 cents per foot of tile laid.

Water-stage recorders are installed in V-notch weir boxes at each drain outlet to record rates of flow and total volume of drain effluent. Piezometers and open wells are being installed in the vicinity of each drain and extending across the area between drains for observation of the influence of different filter materials on water table topography. Observation points will be established in the area surrounding the field under study to determine the boundary conditions affecting each drain.

At the end of 3 years of study, sections of each tile line will be excavated to further evaluate the performance of filter materials by measuring the amount of movement of base material into and through the tile joints.

This study is part of a major study on performance of subsurface drainage installations in the Lower Rio Grande Valley of Texas. Additional data will be obtained on the effect of these drains on changes in soil salinity. (II-B-2e)

Texas

WATER TABLE STUDIES IN THE LOWER RIO GRANDE VALLEY

Ronald R. Allen and L. Roy Ussery, Weslaco. --Water table characterization is one of the objectives in an overall study of the "hot spot" problem in the Lower Rio Grande Valley. The 100,000-acre saline affected area lies generally 15 to 30 miles inland from the Gulf of Mexico with mean sea level elevation between 20 and 35 feet. The water table and ground surface both slope approximately 1 foot per mile in a northeasterly direction toward the Gulf.

Normal water table depth is 5 to 12 feet below surface with some fluctuation due to rainfall. Water quality and soil salinity vary considerably in the area. For example, total salts in water samples varied from 1,370 to 32,000 parts per million in a 1/4-mile distance.

Exploration drilling has revealed a fine sand formation under the area. The formation varies in thickness from 10 to 50 feet with the top lying from 8 to 25 feet below surface. Sieve analyses showed approximately 50 percent of the sand remaining on the 80 mesh (0.177 mm. opening) screen. Piezometer batteries show no artesian pressure in the sand formation. (II-B)

Utah

PROCEDURES DEVELOPED FOR FORMING MOLE DRAINS IN THE WEST

Lyman S. Willardson, Logan. --Successful formation of an unlined mole drain was accomplished by pulling a bullet-shaped cylinder 3 inches in diameter on the end of a 7-foot chain behind the mole blade, figure 1. The cylinder re-formed the drain opening after all settlement behind the mole standard blade had occurred.

Attempts to install unlined mole drains in a dry silty clay soil with an ordinary mole standard blade tipped with a 3-inch diameter cylinder were unsuccessful. The moving blade and the mole cylinder shattered the soil and displaced it upward. The displaced soil settled into place behind the blade, filling or partly filling the mole opening. The settlement continued for a distance of 3 feet behind the moving mole blade.

Unlined mole drains subjected to wetting and drying were collapsing after 6 months. One mole drain installed in wet soil and continuously wet is still discharging and is in good condition, figure 2. (II-B)

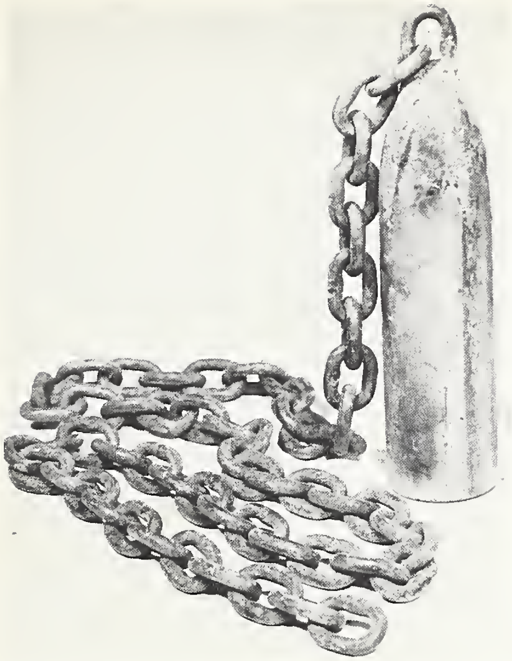


FIGURE 1. --Bullet-shaped cylinder and chain used to form the drain.

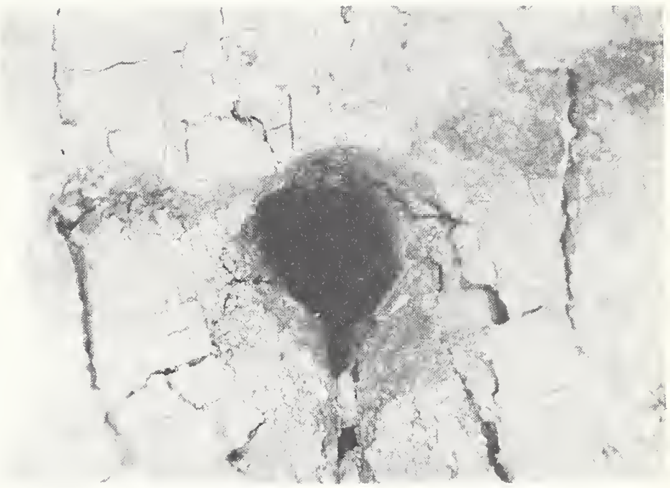


FIGURE 2. --Unlined mole drain.

EROSION AND RUNOFF CONTROL

Iowa

EROSION LOSSES LESS FROM CONTINUOUS CORN HIGHLY FERTILIZED

W. C. Moldenhauer, Ames. --Losses of soil from continuous corn plots heavily fertilized with nitrogen were considerably lower than from rotation corn at the Soil Conservation Experimental Farm near Clarinda, Iowa. The period 1953 through 1959 is used because the plots were changed from uphill and downhill to contour in 1953.

The continuous corn plot which is now receiving 160 pounds per acre of nitrogen was in bluegrass from 1932 to 1946. Corn stover is chopped and spaded under on the continuous corn plots. On the corn-oats-meadow plots the corn stover is chopped and left on the surface. Oats are seeded in the mulch and covered with a simulated disking. Alfalfa and bromegrass are then seeded and raked in. This method of seeding oats and meadows is used almost exclusively in Iowa. Soil loss data, meadow yields, and other treatments are given in the table below.

Meadow stands were poor during the dry years of 1955, 1956, the spring of 1958, and preceding the corn crop in 1958 failed completely. This was undoubtedly the main factor contributing to the high soil losses from rotation corn compared with heavily fertilized continuous corn. Another factor is the fact that the percentage of bromegrass in the one-year meadow is comparatively low, amounting to about 40 percent. The alfalfa-bromegrass mixture has been used, because it is the most commonly used mixture in southwestern Iowa.

Soil losses from the corn-oats-meadow rotation are almost entirely those from corn. Average losses from oats and meadow together were less than 1 ton per acre per year. Thus, losses from corn may be divided by 3 to get the average annual loss from the rotation.

Soil losses per acre from continuous and rotation corn and yields per acre of meadow preceding rotation corn at the Soil Conservation Experimental Farm near Clarinda, Iowa, for the period 1953 through 1959

Crop	Nitrogen fertil-ization	1953		1954		1955		1956		1957		1958		1959		Av. soil loss
		Soil loss	Meadow yield*	Soil loss	Meadow yield*	Soil loss	Meadow yield*	Soil loss	Meadow yield*	Soil loss	Meadow yield*	Soil loss	Meadow yield*	Soil loss	Meadow yield*	
	Pounds/Acre	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
COM	None	8.3	3.6	4.9	1.6	0.8	2.2	3.8	2.0	3.5	1.1	29.8	0	17.2	1.8	9.8
COM	60	8.3	4.0	4.0	1.8	0.4	1.3	8.6	1.9	1.7	0.9	34.8	0	10.7	1.9	9.8
CC	None	17.6	--	13.3	--	2.6	--	5.6	--	2.4	--	13.5	--	17.9	--	10.4
CC	160	17.1	--	11.4	--	2.8	--	2.2	--	0.8	--	8.7	--	5.8	--	7.0
Annual erosion index values....		102		198		--		123		141		448		--		--
Erosion index values by crop periods**																
C_f		0		0		16		1		0		1		--		--
C_1		61		43		21		0		5		9		--		--
C_2		7		22		21		60		45		253		--		--
C_3		21		118		0		45		65		184		--		--
C_4		23		5		2		27		10		2		--		--

* Meadow yields refer to those preceding the rotation corn for each year.
** C_f is the period from turnplowing to planting, C_1 is the period from planting to 30 days later, C_2 is the second 30-day period after planting, C_3 is from the second 30-day period to harvest, C_4 is the period from harvest to turnplowing.

The average annual erosion index for the period 1932 through 1958 was 178. The average for the period 1953 through 1958 (except for 1955) was 202. The 1959 tabulation has not been completed. The annual erosion index of 448 for 1958 was much higher than for any year on record. The next lower value was 355 in 1941. In 1958, 19.28 inches of rainfall were recorded in July compared with an average for 28 years of 4.14 inches. During July 4 storms occurred with erosion indices of 133, 84, 77, and 67, respectively. (IV-A-1)

Missouri

RUNOFF AND EROSION REDUCED BY ROTATIONS ON CLAYPAN SOILS

V. C. Jamison and F. D. Whitaker, Columbia.--The reduction of the time the land is without adequate protective cover is the largest benefit gained by growing corn in rotation with meadow and high fertility treatments on sloping claypan soil. Average runoff losses for the 6-year period (1954-59) were nearly double and erosion losses nearly six times more for continuous corn than for a corn-wheat-meadow-meadow rotation grown on Mexico silt loam with a 3 percent slope (table 1). The runoff loss for the corn growing season averaged 1.3 times more and the soil loss 1.7 times more for continuous corn than for corn in the rotation. These loss ratios were strongly influenced by the losses of runoff and soil resulting from a storm of 10-year recurrence frequency that occurred on June 29-30, 1957. This one storm accounted for about one-third of the runoff and one-half of the soil loss during the corn-growing season for both continuous and rotation corn over the full 6 years of the study. High fertility treatments were used for both systems.

More than two-thirds of the runoff and 96 percent of the soil loss occurred during the corn-growing season for continuous corn. With the 4-year rotation, 25 percent of the total rotation runoff and 85 percent of the soil loss occurred under corn during the corn-growing season.

TABLE 1.--Soil and water losses under corn grown continuously and in a sod-based rotation

Period	Runoff		Soil loss per acre	
	Cont. corn	Rotation[1]	Cont. corn	Rotation[1]
	Inches	*Inches*	*Tons*	*Tons*
Annual 6-year av. (1954-59).............	1.63	0.87	1.60	0.27
Loss from cornland during corn growing season[2] (1954-59).....................	1.11	0.86	1.53	0.92
Loss from cornland during high intensity storms (6/29-30/57)..................	2.07	1.73	4.37	2.53

[1] Corn-wheat-meadow-meadow.
[2] Period from plowing for corn until harvest.

The annual average rainfall--erosion index was not as high for the 6-year period studied as for a longer period of record (table 2). However, the average for the critical period for corn (fallow plus first 30 days) is a little more for the 6-year than for the 19-year period. Thus, the average annual losses for the 6-year period of the experiment probably represent a slightly higher amount than the expected average losses. The rainfall-erosion index for the high intensity series of storms (June 29-30, 1957) had a combined value of 94. A storm of this magnitude may be expected about once in 10 years.

TABLE 2.--Rainfall-Erosion index values by crop stage periods for continuous corn, McCredie, Mo.

Crop period	Rainfall-erosion index values	
	19-year av. (1941-59)	6-year av. (1954-59)
Fallow..	19	18
0-30 days after planting..........................	26	36
30-60 days after planting..........................	39	40
60-120 days after planting..........................	78	42
120 days after planting to fallow................	38	43
Annual av..	200	179

However, the probability of a storm with such a high erosion potential occurring during the critical fallow-early growth period for corn may be once in a higher number of years. (IV-A-1)

TABLE 3.--Probability of storms occurring with rainfall-erosion index values given at Columbia, Mo.

Expected frequency	Rainfall-erosion index 0.01 x foot - tons x inches/hour
2-year.......	51
5-year.......	75
20-year......	107
100-year.....	145

Nebraska

RUNOFF RATE PROVIDES MEASURE OF WATER IN FURROW

Norris P. Swanson, Lincoln.--The rate of runoff from a furrow at the end of a storm provides a measure of the surface water in the furrow watershed at that time.

Storm intensity and furrow length, slope, and cross section are important factors affecting the amount of free water stored in a furrow at the end of a storm. Analysis of data from a number of simulated storms, with varying crop, slope, and soils, revealed that a linear relationship exists between the furrow detention (L^3) and the runoff rate at the end of the storm. The furrow detention was obtained from the total runoff occurring from the furrow after the storm. Some infiltration takes place during the time required for drainage of the furrow, but this is assumed to be of minor importance.

The figure shows the relation of furrow detention and the respective end of storm runoff rates for three successive simulated storms on an irrigated potato field. These furrows were 600 feet long with a 1.6 percent slope.

A rule of thumb procedure for furrow irrigated fields with uniform slopes is indicated from a survey of the data at hand. Furrow detention in gallons equals 4 to 5 times the end of the storm discharge in gallons per minute.

Further analysis will be required to evaluate the relation of storm intensity and furrow slope, cross section, spacing, and length in determining furrow detention. (II-A-4, 10; V-H-2)

Nebraska

RUNOFF STREAM VELOCITIES APPEAR UNIFORM ALONG A FURROW

Norris P. Swanson, Lincoln.--The instantaneous maximum velocity of a runoff stream was essentially uniform along the length of a furrow on a majority of 39 sets of recorded velocities studied. The velocities of runoff streams in furrows were measured at four uniformly spaced stations using a salt injection technique. The runoff was obtained from simulated rainfall on furrows with uniform grades and 400- to 600-foot lengths of run.

If only minor changes of the hydraulic radius and very minor changes of the roughness coefficient occur between successive stations, uniform velocities can be anticipated. Under such conditions it can be assumed that the velocity equals a constant times the square root of the slope, and in these furrows the slopes were also constant.

Parallel furrows (same plot) with similar discharges had similar velocities. Where a higher simulated rainfall intensity provided greater runoff from a furrow, increased velocities were also measured. Velocities measured early in a storm were lower than those measured when peak discharge was imminent or had been reached. Changes in the roughness coefficient are undoubtedly responsible for velocity differences between furfows and velocity changes in a furrow during a simulated storm. (II-A-4 and II-A-10)

Wisconsin

CORN STOVER MULCH LOWERS SOIL AND WATER LOSSES

R. E. Taylor and O. E. Hays, LaCrosse.--The soil and water losses from continuous corn with corn stover mulch have been markedly lower than from corn in a corn-oats-meadow rotation during the period from 1954-1959.

The use of corn stover as a surface mulch has reduced annual runoff losses by 34 percent and annual soil losses by 89 percent as compared to losses from rotation corn.

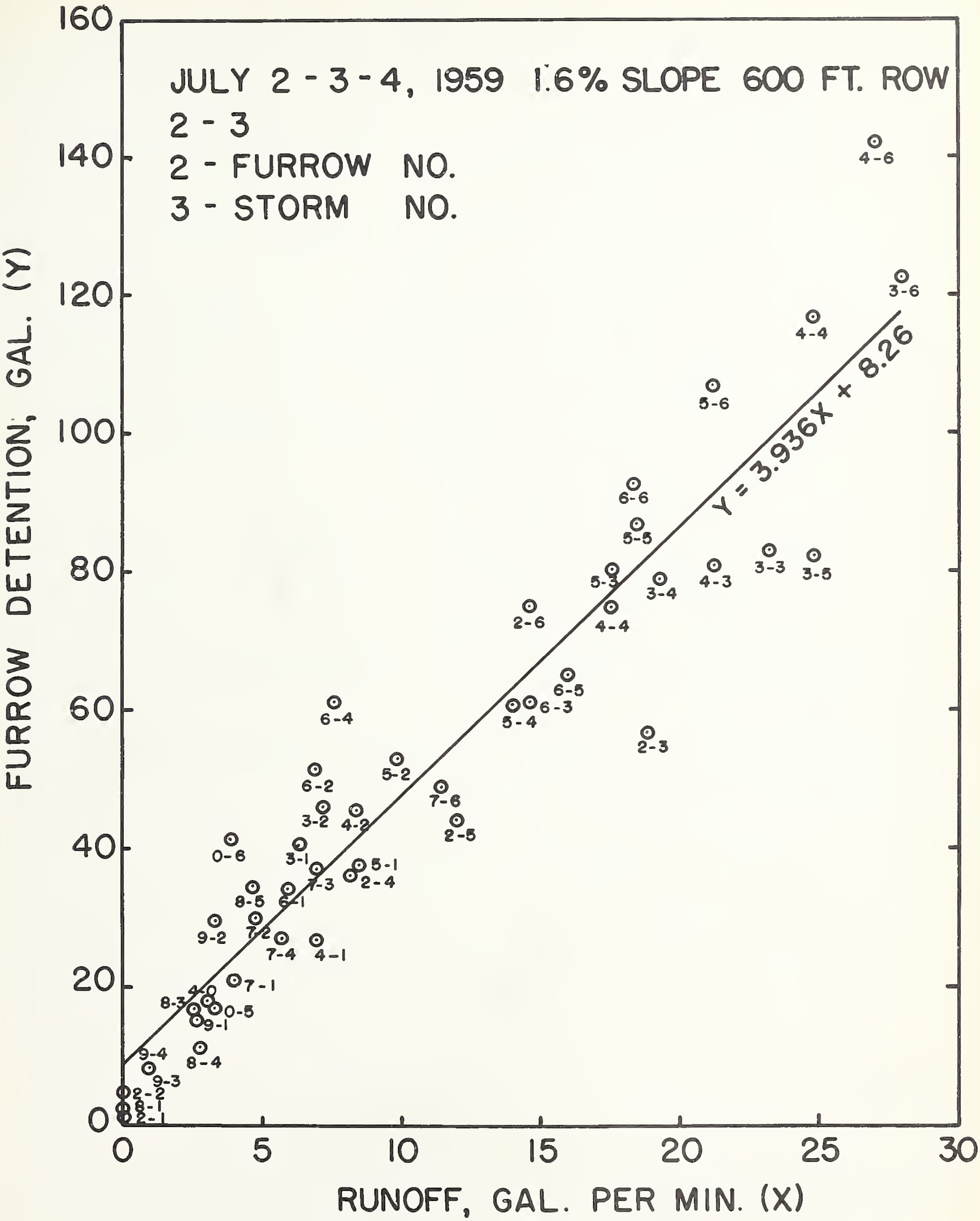


FIGURE 1. --Furrow detention compared with runoff rate (end of storm), potatoes, Stroh Farm, Johnstown, Colorado.

Growing season losses were reduced 81 and 92 percent for runoff and soil loss, respectively. (See table 1.) Generally the major part of the total runoff occurs in the winter period but with low amounts of soil loss. Winter runoff is influenced to an unknown extent by drifting snow across the plot areas resulting in an uneven snow cover.

The plots located on a 16 percent slope are one-hundredth acre in size. The manure and fertility treatments are uniform on corn except that each ton of mulch receives 15 pounds of nitrogen. Corn is planted at 16,000 plants per acre in 40-inch row spacing.

TABLE 1.--Annual runoff and erosion losses by crops

Year annual	Continuous corn		3-year rotation						Rotation average	
			Corn		Oats		Hay			
	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss
	Inches	*Tons/A*	*Inches*	*Tons/A*	*Inches*	*Tons/A*	*Inches*	*Tons/A*	*Inches*	*Tons/A*
1954	0.06	0.07	1.23	5.60	4.12	24.53	0.26	0.47	1.87	10.20
1955	.46	.63	2.47	1.16	1.41	5.31	2.08	2.38	1.99	2.95
1956	2.72	--	3.94	.01	2.55	.27	4.31	.10	3.60	.13
1957	.74	.02	2.25	1.10	1.48	1.21	.92	.02	1.55	.78
1958	.86	--	.67	0	.92	.03	.84	--	.81	.01
1959	6.14	.62	6.16	4.26	7.18	20.08	5.81	.15	6.38	8.16
Total	10.98	1.34	16.72	12.13	17.66	51.43	14.22	3.12	16.20	22.23

The average 3-year rotation soil loss has been 1.8 times higher than that of rotation corn due to the high losses from oats. (See table 2.) Soil losses from hay were higher than from continuous corn during 3 of the 6 years.

The number of intense rains occurring during this study has been below the long-time average for this location. There have been but two storms which have equaled or exceeded the 2 year storm.

TABLE 2.--Erosion Index value of 57

Comparative soil and water losses for intense rains

Date of rain	EI value	Continuous corn		3-year rotation corn		Rotation average	
		Run-off	Soil loss	Run-off	Soil loss	Run-off	Soil loss
		Inches	*Tons/A*	*Inches*	*Tons/A*	*Inches*	*Tons/A*
July 21, 1957	69	0.01	--	0.07	0.03	0.07	0.02
Aug. 26-27, 1959	185	.30	.52	.81	3.87	.40	2.00

An EI value of 69 can be expected once in 2 years, while one of 185 can be expected once in 20 years. The average annual EI value for the 1933-1958 period is 166, while that for 1954-1958, 120. (See table 3.)

TABLE 3.--Average yearly erosion index values

Date	Crop period					
	C_+	C_1	C_2	C_3	C_4	Annual
1933-1958..	12	30	45	62	22	166
1954-1958..	0	34	46	29	11	120

C_+ Plowing to planting; C_1 Seedbed - 30 days; C_2 Establishment - 30 days; C_3 Growing Crop - 60 days; C_4 Residue.

The average EI values by corn growth periods 1 and 2 for the 1954-1958 period were close to those for the 1933-1958 period, but average EI values for corn periods 3 and 4 were considerably lower. The critical periods from the standpoint of crop cover, however, are in the early growth periods of corn - C_1 and C_2.

The data thus far indicate that continuous corn can be raised on short slopes up to 16 percent without experiencing high soil and water losses if the stover is returned to the surface and maintained there throughout the year. (IV-A-1)

SOIL FERTILITY

Alabama

GRASSES DIFFER IN THEIR EFFICIENCY TO USE NITROGEN

O. L. Bennett, B. D. Doss, and D. A. Ashley, Thorsby.--In an experiment where nitrogen was applied to irrigated Coastal Bermudagrass, Pensacola bahiagrass, and dallisgrass in five equal applications in order to obtain maximum utilization, Coastal Bermudagrass was the most efficient user of applied nitrogen of the three grasses tested during a 2-year period.

Rates of nitrogen applied, forage yields, and nitrogen recovery data are presented in the table. Forage yields increased as rate of nitrogen was increased each year. The efficiency of nitrogen utilization decreased as rate of application increased as shown by the pounds of forage produced per pound of N applied. The percent recovery of applied nitrogen tended to decrease as rate of application was increased. Both Coastal Bermudagrass and bahiagrass yields and nitrogen recovery rates were considerably higher than for dallisgrass. Dallisgrass stands did not persist where high rates of nitrogen were used and were completely gone at high rates of nitrogen by the end of the second year.

Yields of Coastal Bermudagrass were still increasing at the 900-pound rate of nitrogen with a recovery rate of approximately 60 percent. This would indicate that even higher rates of N could be used before maximum yields are reached. The 600 pounds of N per acre rate of N on bahiagrass produced maximum yields. (V-D-2)

The effects of rates of nitrogen on yield and nitrogen recovery of three summer grasses, Thorsby, Ala., 1957-58

Year	Specie	Rate of N applied	Forage yield	Forage produced/lb. N applied	Nitrogen removed in plants	Nitrogen recovered
		Pounds per acre	*Pounds per acre*	*Pounds*	*Pounds per acre*	*Percent*
1957.........	Coastal	0	3,117	--	39	--
	Bermudagrass	150	10,437	70	150	74
		600	18,811	31	457	70
1958.........		0	3,861	--	49	--
		300	15,959	53	288	80
		900	22,628	25	582	59
1957.........	Pensacola	0	3,845	--	44	--
	bahiagrass	150	9,238	62	120	51
		600	20,756	35	394	58
1958.........		0	2,893	--	38	--
		300	14,001	47	235	66
		900	17,571	20	371	37
1957.........	Dallisgrass	0	1,655	--	16	--
		150	5,566	37	69	51
		600	10,197	17	244	58
1958.........		0	1,882	--	24	--
		300	8,833	29	170	49
		900	10,944	12	273	27

Arkansas

COASTAL BERMUDAGRASS SHOWS LITTLE RESPONSE TO LIME

C. D. Foy, Fayetteville.--Coastal Bermudagrass has shown a tremendous tolerance for soil acidity in tests which have run for 2 years on four different soil types in Arkansas.

The four soil types used had an initial pH of from 4.9 to 5.4. Treatments included dolomitic and calcitic limestone disked into the soil surface and dolomitic limestone plowed under. (In one test, one-half the lime was plowed under and one-half disked into surface after plowing.) Rates of lime tested were 0, 1, 2, 4, and 8 tons. Fertilization during year of stand establishment was 235 pounds of nitrogen, 220 pounds of phosphate, and 220 pounds of potash. During 1959 all plots received 400 pounds of nitrogen in four equal applications with phosphate and potash applied in amounts estimated necessary for maximum yield.

The lime treatments resulted in a pH range of from 4.8 to 7.3. Under this wide variation of soil acidity, the yields from all plots were about the same--around 7 tons per acre. One soil, Johnsburg silt loam, gave small but significant yield increases with either the 4- or 8-ton lime treatments. No yield differences occurred between lime sources and placements.

While Coastal Bermuda can grow well under very acid conditions, a potentially serious problem will develop for crops that may follow it. The continued use of nitrogen fertilizer on the grass increases soil acidity, not only in the surface layers where lime can readily correct it but deep in the profile as well. Furthermore, a point may be reached, as indicated by the response obtained in the one experiment above, where lime will be required for maximum yield of Coastal itself. For these reasons, lime should be used on Coastal Bermuda sod, especially if moderate to high rates of nitrogen are applied. (V-D-1)

California

NUTRIENT DEFICIENCIES IN SAN FRANCISCO BAY SEDIMENTS

Barby R. Carroll, Berkeley.--A combination of nitrogen and phosphate significantly increased yields on San Francisco Bay sediments in a greenhouse study using Sudangrass planted after excess salts were leached from the muds.

The two sediments, one from Honker Bay (sandy) and one from San Pablo Bay (clay) had a pH of 6.9 and 6.8, respectively. Fertilizer was applied to each soil in triplicate pots of each treatment. Application rates were 200 pounds of nitrogen, 200 pounds of P_2O_5, and 100 pounds of K_2O per acre. Fertilizer treatments and yield of Sudangrass forage are shown in the accompanying table. A combination of nitrogen and phosphate increased yields on both soils, but nitrogen alone caused a significant increase only on the San Pablo soil. Phosphate and potassium or the two combined failed to produce a significant increase in yield.

These preliminary studies only indicate the possible nutrient deficiencies. If these soils are reclaimed, different results may be obtained in the field. (V-D-2)

Effect of nitrogen phosphate and potassium on yields of Sudangrass on two marine sediments, San Francisco Bay, Calif., 1959

Location	Fertilizer treatment[1]	Grams forage per pot
San Pablo Bay........	0-0-0 (check)	3.9
	0-0-5	4.0
	10-0-0	7.8*
	0-10-0	3.9
	10-10-0	11.7**
	0-10-5	3.4
	10-0-5	8.7**
	10-10-5	10.4**
	LSD 5-percent level	2.9
	LSD 1-percent level	4.0
Honker Bay...........	0-0-0 (check)	1.6
	0-0-5	3.0
	10-0-0	2.5
	0-10-0	2.7
	10-10-0	15.4**
	0-10-5	3.3
	10-0-5	1.6
	10-10-5	16.0**
	LSD 5-percent level	3.27
	LSD 1-percent level	4.54

[1] Applied at the rate of 2,000 pounds per acre.
* Significantly higher than the check at 5-percent level.
** Significantly higher than the check at 1-percent level.

Colorado

GASEOUS LOSS OF NITROGEN HIGH ON SOME SOILS

Francis E. Clark, Fort Collins.--Gaseous losses of applied nitrogen may be high even on well-aerated soils. For cropland generally, the nitrogen lost to the atmosphere has been estimated at 20 percent annually of the available soil nitrogen. Among soils this loss is by no means uniform. In some, the loss is negligible, in others, it may total 50 percent. A laboratory study just completed links the differing volatile nitrogen losses from soils to differences in their nitrifying capacities.

Volatile losses were found to occur especially from soils which accumulated nitrate nitrogen during nitrification of ammonium nitrogen and which were either initially acid in reaction, or, if initially alkaline in reaction, were poorly buffered soils that became acid during the course of the nitrification process. Some representative data are shown in the accompanying table.

Recoveries of applied mineral nitrogen from experimental soils

Soil No.*	Soil pH		Applied nitrogen recovered as:			Applied nitrogen not recovered
	Initially	After incubation	Ammonium N	Nitrite N	Nitrate N	
			Percent	*Percent*	*Percent*	*Percent*
1..............	6.3	5.0	16	0	74	10
2..............	8.0	7.5	0	0	92	8
7..............	7.9	7.3	0	0	93	7
12..............	8.1	7.4	0	0	88	12
13..............	8.0	6.7	2	0	88	10
22..............	7.9	7.1	1	0	88	11
23..............	6.7	4.4	11	0	75	14
25..............	8.2	7.3	1	0	92	7
26..............	7.5	7.3	1	0	91	8
27..............	6.0	4.5	6	0	88	6
4..............	7.1	6.6	31	8	30	31
5..............	7.4	7.0	27	37	3	33
6..............	7.2	5.9	24	10	28	38
9..............	7.5	6.6	25	16	27	32
11..............	7.7	6.8	25	32	2	41
14..............	7.3	6.8	25	29	8	38
17..............	7.5	6.8	28	36	1	35
19..............	6.7	6.4	28	18	11	43
24..............	6.5	5.8	27	6	38	29
32..............	7.5	6.6	26	20	19	35

*Soils 1, 2, 7, 12, and 13, Fort Collins silt loam from near Fort Collins, and Greeley, Colo.; 25, Sagemoor f.s.l., Prosser, Wash.; 22, 23, 26, 27 and 19, 24, 32, unidentified Columbia Basin soils, some probably are Ritzville f.s.l.; 4 to 6, 9, 11, 14 and 17, sandy loams, probably Gilcrest s.l., from near Gilcrest and Wiggins, Colo.

In summary, the first 10 soils listed show an average nitrogen deficit of only 9.3 percent. These soils did not accumulate nitrite. They did show rapid accumulation of nitrate. Conversion of the applied nitrogen to nitrate averaged 87 percent during 4 weeks of incubation.

The second 10 soils listed show an average nitrogen deficit of 35.5 percent. In these soils, conversion to nitrate accounted for only 16.6 percent of the applied nitrogen, whereas nitrite accumulation accounted for 21.4 percent. The pH value in these soils at the time nitrite was present was 7.0 or lower. These data suggest that nitrite instability, rather than enzymatic denitrification or volatilization of ammonia, is primarily responsible for the nitrogen losses that were measured.

Georgia

DRY SOIL REDUCES FOLIAR UPTAKE AND MOVEMENT OF PHOSPHORUS

J. E. Pallas and G. G. Williams, Watkinsville.--A decrease in available soil moisture decidedly decreases the foliar absorption and translocation of phosphorus.

A very striking effect on the uptake and movement of phosphorus as influenced by soil moisture tension was found in red kidney bean plants grown under semi-controlled conditions. A solution tagged with radioactive phosphorus was applied to the leaves as small drops. The experimental temperature was 28° C. with a relative humidity of 38 percent. A range of soil moisture tensions was established ranging from dry (approximately 12 atmospheres) to wet (less than 0.2 atmospheres) in Cecil clay loam in which the plants were growing. None of the plants visibly wilted. Harvests were made 4 hours after treatment.

More radioactive phosphorus was absorbed and eight times as much translocated at the lowest tension when compared to the highest tension. The upper right autoradiogram (see accompanying figure), when compared with the autoradiogram on the upper left, indicates a marked decrease in movement of phosphorus throughout the plant at the higher moisture tensions of the drier soil.

In a previous study soil moisture has also been found to have an effect on the translocation of a foliarly applied herbicide but not on its uptake.

Although field testing is lacking this work gives every indication that the moisture status of the soil plays an extremely important role in the efficient use of foliar applications. This discovery may be of significance in improving the efficiency of spray-applied nutrients.

The foliar method of applying phosphate is not used to any extent in this country at the present time. However, it is a common practice in some foreign countries. (V-D-1)

Distribution of P^{32} in bean plants as effected by available soil moisture. (Lower left) Plant treated near field capacity; (Upper left) autoradiogram of this plant; (Lower right) plant treated at higher moisture tension (about 4 atmospheres); (Upper right) autoradiogram of this plant.

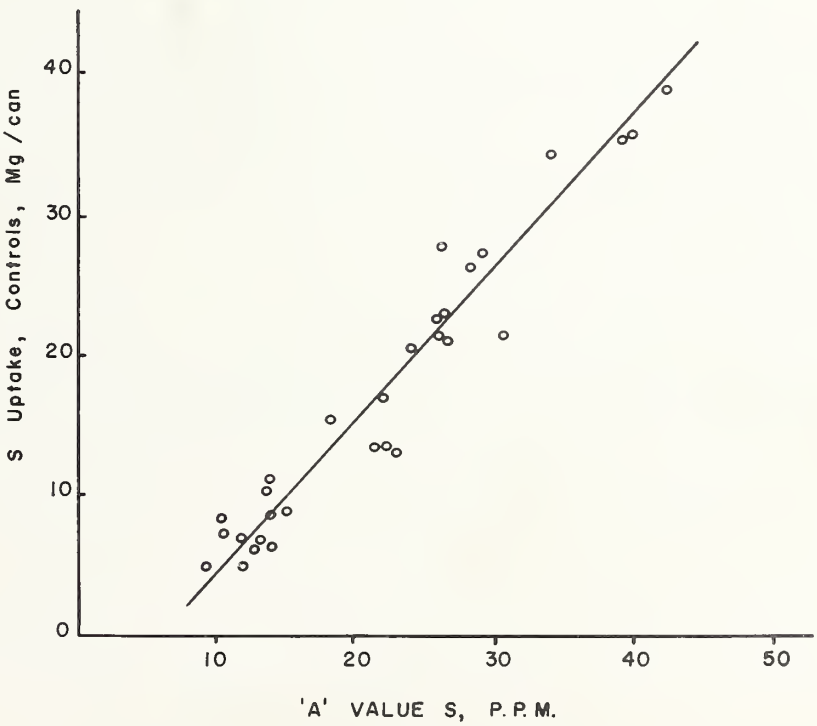
Maryland

AVAILABLE SULFUR MEASURED BY RADIOACTIVE TECHNIQUE

D. C. Nearpass, Beltsville.--Radioactive sulfur can be used to measure available sulfur in soils when "tagged" sulfur fertilizer is applied to soils, and plants are grown therein. The plant takes up both the "tagged" sulfur and native soil sulfur. Since the sulfur fertilizer is "tagged," both the amount of sulfur taken up from the fertilizer and the amount of sulfur taken up from the soil can be measured. From these measurements the amount of available sulfur in the soil can be calculated. This measure of available sulfur is called an 'A' value, and it is suggested that the 'A' values can be used as a basis for developing chemical methods for determining available sulfur.

Recent greenhouse and laboratory studies at Beltsville consisted of adding from 0 to 30 p.p.m. of "tagged" sulfur fertilizer to 30 surface and 13 subsoils from the Southeastern United States and growing cotton plants in these soils. After 39 days the plants were harvested, and from the amounts of fertilizer and soil sulfur contained in the plants the available sulfur of the soils was calculated. The calculated 'A' values varied from 10 to 42 p.p.m. of sulfur in the surface soils and from 12 to 100 p.p.m. of sulfur in the subsoils.

A soil test using sodium bicarbonate at pH 8.5 as an extractant rated these soils the same as the radioactive procedure for determining available sulfur. The sodium bicarbonate method, based on the 'A' values obtained in the greenhouse experiment, offers a reliable procedure for predicting the sulfur needs of soils for adequate plant growth. (V-D-2)



Relationship between sulfur uptake by plants which received no fertilizer sulfur and available soil sulfur, as measured by isotopic dilution, from plant uptake. Beltsville, Maryland.-- 1959.

LAND LEVELING EXPOSES SUBSOILS DEFICIENT IN NUTRIENTS

Joe O. Sanford, State College. --Land leveling may expose subsurface horizons in the Mississippi Delta which are relatively less productive and frequently deficient in sulfur. This was demonstrated in a greenhouse-cropping study made on profiles of four important soil series.

Cotton was grown in greenhouse cultures on horizons of two profiles each of the Dubbs, Dundee, and Bosket soil series and on three profiles of the Forestdale series. Fertility treatments included nitrogen, phosphorus, and potassium in various combinations and calcium and sulfur in combination with all three.

A summary of the mean yields over all treatments on successively lower horizons of the four soil series is shown in the table below. In general, yields were greatest on surface horizons and decreased on successively lower horizons in the profile, particularly on the B2 and C horizons. Cuts extreme enough to expose these horizons are not common in land-leveling operations, but they do occur.

Cotton yields on successive horizons of four Delta profiles

Horizon	Cotton yields[1] - grams oven-dried plant material			
	Soil series			
	Dubbs	Dundee	Bosket	Forestdale
	Gm./culture	*Gm./culture*	*Gm./culture*	*Gm./culture*
Ap	5.2	4.8	2.1	4.9
B_1	5.9	1.8	2.0	3.0
B_2	2.8	1.5	1.6	1.6
C	2.4	1.4	1.9	1.8

[1] Mean yields over all treatments.

The most general deficiency evident in cotton growing on subsurface horizons was that of sulfur. The addition of sulfur was beneficial on five subsurface horizons of the Dundee soils, on two subsurface horizons of the Bosket series, and on two subsurface horizons of the Forestdale series. There was no response to sulfur on surface horizons of any of these soils. In the case of the Dubbs series neither the surface nor the subsurface horizons responded to sulfur.

Cotton growing on horizons of Dundee silt loam. The stunted chlorotic plants on subsurface horizons show sulfur deficiency symptoms.

The accompanying photo shows cotton growing on horizons of Dundee silt loam. Stunted chlorotic plants due to sulfur deficiency are evident on the subsurface horizons. (V-H-2)

Mississippi

WINTER STORAGE OF SOIL N IS INEFFICIENT IN THE SOUTH

Howard V. Jordan, State College. --Fall-applied nitrogen averaged only 55 percent as effective in increasing corn yields the following year as the equivalent rate of nitrogen applied in spring in the conventional manner.

This sizable loss of effectiveness rules out any hope for storing nitrogen over-winter in the soil for the next season's crop. Low over-winter losses in some of the North-Central and Plains States had encouraged farmers and some segments of the fertilizer industry to look hopefully toward fall application in the South. If such were feasible, nitrogen sales could be made less seasonal, storage costs reduced, and the labor load on farms could be more evenly distributed. Unfortunately conditions in the South are such that fall-application, except on actually growing crops, is not desirable.

The conclusion on fall application was reached from three experiments in Alabama, one in Georgia, and two in Mississippi which extended over a 4-year period. The experimental locations covered a range in soil texture from clay to sandy loam, annual rainfall varied from 50 to 62 inches, and there were from 23 to 69 days with freezing temperatures during the course of the experiments. The results did not differ widely from the general mean at any single location, although at a given location the efficiency of fall-applied nitrogen might vary considerably in different years.

There was some variation in comparative effectiveness between certain locations and years. Difference in effectiveness among years may be explained in part by differences in winter rainfall and the consequent losses by leaching and erosion, although these differences do not fully account for the divergence in results. More probably certain combinations of winter temperatures favorable to microbial conversion from less labile forms to soluble nitrates followed by leaching rains are responsible for larger losses in some years. Losses by volatilization probably also occurred.

Nitrogen materials used for fall application were ammonium sulfate, ammonium nitrate, sodium nitrate, urea, and anhydrous ammonia. There were no large or consistent differences in effectiveness among these materials. Nitrate of soda usually compared favorably with ammonium nitrate and ammonium sulfate. Urea was consistently among the most effective sources in some experiments, but was not so favorable in others. Results with anhydrous ammonia were the most variable, due to the difficulty in accurately metering this material. As an average, maximum differences in yield obtained with the various sources was about 3 bushels of corn per acre.

Losses of nitrogen in surface runoff on a Houston clay soil at Brookville, Miss., amounted to more than 25 percent of that applied. On a Ruston sandy loam at Poplarville, Miss., runoff losses of the nitrogen ranged from 2 to 11 percent, depending on the season. Although the runoff studies were limited to two soils, it is obvious that over-winter runoff can remove considerable fertilizer nitrogen from the soil surface. (V-D-2)

FERTILIZING SOD CROPS DID NOT AFFECT WHEAT YIELDS

G. O. Boatwright, and H. J. Haas, Mandan.--Seeding crested wheatgrass or mixtures of crested wheatgrass and legumes to increase succeeding wheat yields appears to be a poor practice in the northern Great Plains.

Plots on Cheyenne fine sandy loam and Agar silt loam were seeded in 1949 to wheat, crested wheatgrass, crested wheatgrass-alfalfa, and crested wheatgrass-sweetclover. Nitrogen alone and in combination with phosphorus was applied to some of the plots. Plots located on the Cheyenne soil were split by leaving one-half of each plot unharvested--all plant material was mowed and left on the plot from 1949-55--while plant material on the other part of the plot was harvested and removed. Each treatment was replicated three times. In the fall of 1955 all sod plots were plowed, and since that time they have been cropped to wheat without fertilizer applications. Fertilizer was applied throughout the period 1949-59 on plots continuously cropped to wheat.

Wheat yields from plots previously cropped to crested wheatgrass or crested wheatgrass-legume mixtures were not materially greater than from nonfertilized plots continuously cropped to wheat, irrespective of soil series or previous fertilizer treatment. On the other hand, fertilized continuous wheat plots produced more grain than any of the other plots regardless of previous fertilizer application, harvesting treatment, or soil series.

Generally speaking, nonharvested plots produced slightly more grain than harvested plots that received comparable fertilizer applications.

Although the use of sod crops failed to increase wheat yields, it should be pointed out that early growth responses were noted owing to the previous crested wheatgrass and alfalfa crop. Evidently the grass-legume crop depleted soil moisture and current precipitation was not sufficient to produce the increased yield potential that existed early in grain development following the grass-alfalfa crop. (V-D-2)

Average wheat yield from two different soil series as influenced by previous cropping, fertilization, and harvesting treatment, 1956-1959

Previous cropping	Annual fertilizer treatment per acre 1949-55		Yield per acre on		
			Cheyenne fine sandy loam		Agar silt loam
	N	P_2O_5	Harvested	Nonharvested	Harvested
	Pounds	*Pounds*	*Bushels*	*Bushels*	*Bushels*
Wheat....................	0	0	15.6	15.3	11.9
Do....................	30	30	20.1	20.8	16.3
Crested wheatgrass.......	0	0	15.8	18.4	--
Do....................	30	0	14.4	15.7	11.9
Do....................	30	30	16.6	16.8	12.1
Do....................	60	0	15.6	17.1	12.7
Do....................	60	30	16.1	18.0	12.1
Crested wheatgrass and alfalfa............	0	0	13.2	15.0	11.4
Do....................	0	30	16.5	14.7	12.1
Crested wheatgrass and sweetclover...........	0	0	14.8	16.4	--
Do....................	0	30	14.3	16.0	--

Puerto Rico

SOIL ACIDITY AFFECTED BY NITROGEN SOURCE

Fernando Abruna and Jose Vicente-Chandler, Rio Piedras.--Soil acidity and lime requirement are strongly influenced by the kind of nitrogen fertilizer used.

In an experiment on Catalina clay in Puerto Rico ammonium sulfate, urea, ammonium nitrate, and sodium nitrate were compared as sources of nitrogen for Napiergrass. Although no difference was found between these fertilizers in forage production, there were marked differences in their effect on soil acidity and lime requirement. The application of 600 pounds of nitrogen as ammonium sulfate during a 1-year period caused an increase in soil acidity equivalent to more than 2-1/2 tons of limestone. The effect of ammonium nitrate and urea was less drastic, requiring about one ton, while sodium nitrate caused a decrease in soil acidity.

N source applied at 600 pounds nitrogen per acre	Pounds $CaCO_3$ required annually to counteract residual acidity
Ammonium sulfate	5,400
Ammonium nitrate	2,200
Urea	1,800
Sodium nitrate	-1,600

Although most of the change in acidity occurred in the surface soil, deeper layers were also affected. This creates a more serious problem because of the difficulty in correcting subsoil acidity.

Residual acidity of ammonium sources of nitrogen is a problem of increasing importance in the naturally acid, poorly buffered soils of the Southeastern and Eastern United States. Results similar to those reported here have been found on soils such as the Cecil Norfolk, and Hartsells. (V-D-2)

Puerto Rico

SUN-GROWN COFFEE BEARS HEAVILY, RESPONDS TO N AND K

F. Abruna and J. Vicente-Chandler, Rio Piedras.--Experimental plantings of intensively managed sun-grown coffee have produced as much coffee in 4 years as the average extensively managed, shade-grown plantation produces in 50 years. The plantings continue to respond very strongly to fertilization with N and K this year.

Pounds of market coffee produced per acre during 4 years' experimentation are shown below:

1956	1957	1958	1959	Average
2,170	1,674	1,600	1,870	1,828

The yearly average yield of 1,828 pounds per acre contrasts with the Island-wide average of 150 pounds for shade-grown coffee.

Pounds of market coffee produced per acre in 1959 with varying N and K fertilization are shown below. Rates were varied with the other fertilizer elements present in abundance.

Pounds of nutrient applied per acre yearly	Nitrogen	Potash
0	543	858
150	1,437	1,490
300	1,917	1,917

Yields increased sharply with N and K rates up to the highest levels tested, but there was no response to phosphorus fertilization. These results contrast with the general lack of response of extensively managed shade-grown coffee to fertilization. (V-D-2)

Texas

NITROGEN BOOSTS YIELDS AND PROTEIN CONTENT OF BLUE GRAMA

O. R. Lehman and J. J. Bond, Bushland.--An application of 200 pounds of nitrogen per acre tripled seasonal dry-matter production of blue grama when the grass was adequately supplied with water. Four hundred pounds of nitrogen per acre produced four to five times as much dry matter as the unfertilized treatment. Protein content of blue grama increased when nitrogen fertilizer was applied.

Experiments underway at the Southwestern Great Plains Field Station are designed to evaluate blue grama in terms of its production potential when adequate water and nitrogen are applied. Nitrogen in the form of ammonium nitrate was broadcast at the beginning of the growing season, and the plots were irrigated to supply adequate moisture. The soil was a Pullman silty clay loam.

Dry-matter production and percent protein, determined at approximate monthly intervals, are shown in the accompanying table. All forage above a 1-inch height was harvested on each clipping date. Results indicate that the amount and quality of blue grama forage can be materially increased by nitrogen fertilization under favorable moisture conditions.

These data may be helpful in determining the value of blue grama on range sites where supplemental water is provided by water spreading structures or other means. (V-D-2)

Dry matter production and protein content of blue grama as affected by nitrogen fertilization, U.S.D.A. Southwestern Great Plains Field Station 1959

Treatment, Nitrogen pounds per acre	Growth periods					
	May 11-June 2	June 3-July 2	July 3-July 31	Aug. 1-Aug. 27	Aug. 28-Oct. 21	Total season May 11-Oct. 21
	DRY MATTER, LBS. PER ACRE					
0	160	150	170	450	330	1,270
200	560	560	990	1,170	660	3,940
400	610	850	1,860	1,940	800	6,050
LSD (0.05)	94	265	228	462	118	649
LSD (0.01)	143	401	345	700	179	983
	PROTEIN IN FORAGE, PERCENT					
0	6.8	11.3	9.0	8.5	6.5	--
200	14.5	12.3	9.9	9.8	6.3	--
400	17.2	15.0	12.8	12.0	8.1	--
LSD (.05)	1.6	0.9	0.7	1.8	1.4	--
LSD (.01)	2.4	1.3	1.1	2.7	2.1	--

Wyoming

AMMONIUM SULFATE BEST OF THREE NITROGEN SOURCES

Rulon D. Lewis, Laramie.--This study was initiated to compare the results from applications of anhydrous ammonia, ammonium nitrate, and ammonium sulfate on the quantity and quality of forage produced from native mountain meadows irrigated with excessive amounts of irrigation water.

The yields of hay and crude protein produced by the three nitrogen carriers, means of three rates and three locations for 1956 and 1957 are shown below:

Nitrogen carrier	Hay	Crude protein
	Tons per acre	*Pounds per acre*
Anhydrous ammonia	2.9	450
Ammonium nitrate	2.9	482
Ammonium sulfate	3.5	522

The data show that ammonium sulfate produced the highest yield of hay and crude protein. This agrees with other nitrogen tests conducted in Wyoming. The hay and crude protein yields were significantly higher than that produced by anhydrous ammonia.

Compared with ammonium nitrate and sulfate, anhydrous ammonia is much more expensive to apply in native meadow sod, because it has to be placed 3 or 4 inches below the surface in the tough, heavy sod common in wet meadows. The ammonium nitrate and sulfate need only be spread over the surface of the sod, which is a much cheaper operation. All yields are low because of the excessive amounts of irrigation water applied, a common but undesirable practice. (VI-A-3)

CROPPING SYSTEMS

Georgia

ALFALFAS DOMINANT OVER GRASSES IN MIXED STANDS

B. H. Hendrickson, Watkinsville.--At the end of 4 years, five cool-weather grasses were seriously suppressed, or had died out, when grown in combination with two alfalfa varieties.

The five grasses were planted in 20-inch drill rows with the expectation that this spacing would give the broadcast alfalfas a better chance to develop good stands against the severe grass competition. However, for three of the grasses the reverse happened. Orchardgrass, bromegrass, and tall fescue were suppressed by the alfalfas. Orchardgrass--the best of the three--in 3 years time made up less than one-third of the stand with Arizona alfalfa, and only one-twelfth with Kansas alfalfa.

For the annual rescue and ryegrass (both reseeding types) the situation was different. The ryegrass especially "got the jump" on the alfalfa seedlings and had to be cut back along with the young alfalfa plants early in the first spring. Thereafter, for the next 3 years ryegrass made up as much as 40 percent of the mixed forage; rescue much less. Both of these grasses disappeared completely in the fourth year leaving pure alfalfa stands. The successive hay cuttings finally prevented grass seed production.

Four harvests were made annually from triplicate plots on Cecil sandy loam, Class II land, total forage yields ranging within 4.00 and 5.00 tons per acre. A high level fertilization schedule was maintained, including 100 pounds nitrogen per acre for the grasses.

When grown in this manner, the five grasses used did not successfully form a compatible forage crop mixed stand with alfalfa in this area. Of the two alfalfa varieties used, Kansas was somewhat more dominant and productive than Arizona. All five of the grasses made their best growth in the spring seasons. (VI-A-1)

Georgia

CORN YIELDS IMPROVED IN ROTATION EXPERIMENT

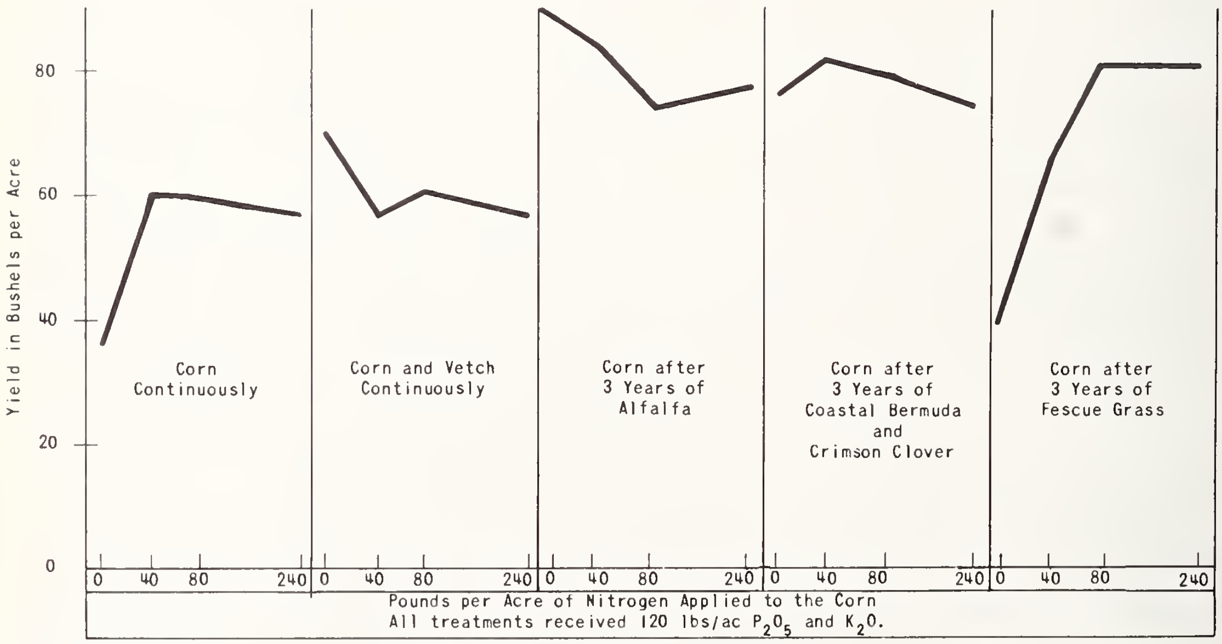
William E. Adams and J. R. Carreker, Watkinsville.--At the end of the first 4-year cycle corn yields in the rotation experiment initiated in 1955 showed varying responses to nitrogen fertilization. Nitrogen increased yields markedly in the continuous corn and the corn after 3 years of fescue grass rotation. Corn in the alfalfa rotation produced 75 bushels per acre at all nitrogen levels, indicating that alfalfa supplied all the nitrogen the corn could use in 1958 and 1959 when rainfall was deficient during July and August. Other trends are shown in the figure.

All turning, planting, and cultivation was with conventional equipment. Fescue sod required a heavy disking ahead of turning and one or two extra diskings following turning to cut up the sod. No extra preparation was necessary with alfalfa or Coastal Bermuda sods.

Both alfalfa and fescue had to be reseeded following corn harvest. Coastal Bermuda re-established itself in the corn and provided excellent protection against soil and water loss during the late summer.

Following corn harvest the stalks were cut and crimson clover was seeded in the Coastal Bermuda without additional tillage. The crimson clover provided from 1 to 1-1/2 tons per acre of dry forage and extended the grazing period about 6 weeks over Coastal Bermuda without clover. The corn stalks, clover, and dead Coastal Bermuda afforded some grazing for beef cattle during the fall and winter as well as excellent protection to the soil during the same period. (V-A-1)

YIELDS OF CORN IN 1958 FROM 5 CROPPING TREATMENTS ON CECIL SANDY LOAM, CLASS II LAND, AT THE SOUTHERN PIEDMONT CONSERVATION FIELD STATION, WATKINSVILLE, GEORGIA



Interpretations:

1. Corn yields were best after alfalfa and Coastal Bermuda grass - crimson clover.
2. Nitrogen improved yields to 40 lb/acN. without cover crops and to 80 lb/acN. after fescue, but was not beneficial where legumes preceded the corn.

Data taken from SPCFS 1958 Summary of Progress

Georgia

SOD-SEEDED ABRUZZI RYE SUCCESSFUL ON COASTAL BERMUDA SOD

H. G. Ukkelberg, Fleming. --Sod-seeded abruzzi rye on Coastal Bermuda sod produced higher liveweight gains of steers on Bladen and associated soils than rye seeded on a prepared seedbed in 1959 and 1960.

Furthermore, beef gains and forage yields during the following summer were as high from the Coastal bermudagrass which had been previously sod-seeded with rye as from the grass which had not been sod seeded, showing that sod seeding does not injure the Coastal bermudagrass. The results are presented in the table.

Heavy rainfall occurred both years, and was a factor in the results. More than twice normal rainfall occurred during the grazing period in 1959. This excessive rainfall resulted in boggy conditions in the prepared seedbed plots, and some of the forage was lost in trampling into the wet boggy soil. This did not occur on the sod-seeded plots.

The sod seeding operation can be performed earlier than seeding on a prepared seedbed in a year of high rainfall such as occurred in the fall of 1959. This is especially true on heavy soil such as the Bladen. The sod seeding was delayed 3 weeks because it was not possible to seed on the prepared land until 7 weeks later than normal. The date of seeding is an important factor in the amount of forage that can be produced from fall-seeded rye.

Forage yields as determined by clipping caged areas were higher from the prepared seedbed plots than from those sod seeded. However, no forage was lost from trampling in these caged areas. (VI-A-1)

Beef production and forage yields from Abruzzi rye sodseeded and seeded on prepared seedbed and from Coastal Bermudagrass the following summer

Treatment	Year	Average steers per acre	Liveweight gains			Total forage yields
			Per acre	Per steer	Daily gain per steer	
Abruzzi rye		*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds**
Sod-seeded...............	1959	1.03	190	185	1.88	2,658
	1960	.93	116	122	1.47	1,674
Average................		.98	153	154	1.67	2,166
Prepared seedbed.........	1959	1.47	172	117	1.20	3,994
	1960	.76	105	143	1.65	2,217
Average................		1.11	138	130	1.42	2,975
Coastal Bermudagrass						
Previously Sod-seeded..	1959	1.70	196	115	.82	9,720
Not sod-seeded...........	1959	1.52	169	111	.79	9,510

*16 percent moisture.

Iowa

YIELDS FROM CONTINUOUS CORN AS GOOD AS FROM ROTATION CORN

W. C. Moldenhauer, W. D. Shrader, and John Pesek, Ames.--Yields of continuous and of rotation corn have averaged about the same at six locations in Iowa over the past 6 years. In another experiment at the Agronomy Farm near Ames, one set of plots has been in corn continuously since 1915. When adequate fertilizer was applied, starting in 1952, yields on these old continuous corn plots increased to levels as high as the rotation corn.

In the work with continuous corn at Ames it was easy to push continuous corn yields to high levels. But as shown in the table this is not always the case. Yields of continuous corn at the Pasture Improvement Farm and the Grundy-Shelby Farm in southern Iowa have remained lower than the yields of rotation corn.

In Iowa, 80 to 120 pounds per acre of nitrogen are required annually to produce high yields on soils of average fertility. Use of soil insecticides becomes very important where corn is grown continuously. (V-A-1)

Average yields of continuous and rotation corn 1953-1958*

Location	Average yield per acre		Yield of continuous corn as a percentage of rotation corn
	Rotation corn	Continuous corn	
Carrington-Clyde Farm, Independence	*Bushels*	*Bushels*	
Rotation experiment..........................	98	99	101
Runoff experiment...........................	102	97	95
Soil Conservation Farm, Clarinda...............	75	77	102
Pasture Inprovement Farm, Albia................	72	58	81
Southern Iowa Farm, Bloomfield.................	96	105	110
Seymour-Shelby Farm, Seymour...................	76	80	105
Grundy-Shelby Farm, Beaconsfield...............	78	71	92
AVERAGE.......................................	85	84	98

* Taken from Iowa Farm Science reprint number FS-857, "What about continuous corn," by W. D. Shrader, John Pesek, and W. C. Moldenhauer

Minnesota

ALFALFA SUCCESSFULLY INTERSEEDED IN CORN

C. A. Van Doren and R. E. Burwell, Morris.--Alfalfa stands were satisfactory as indicated by fall stand counts in corn planted at 60- and 76-inch spacings in 1959 in western Minnesota. The number of alfalfa plants in October averaged 15.3 plants per square foot in 60-inch rows and 13.2 plants in 76-inch rows.

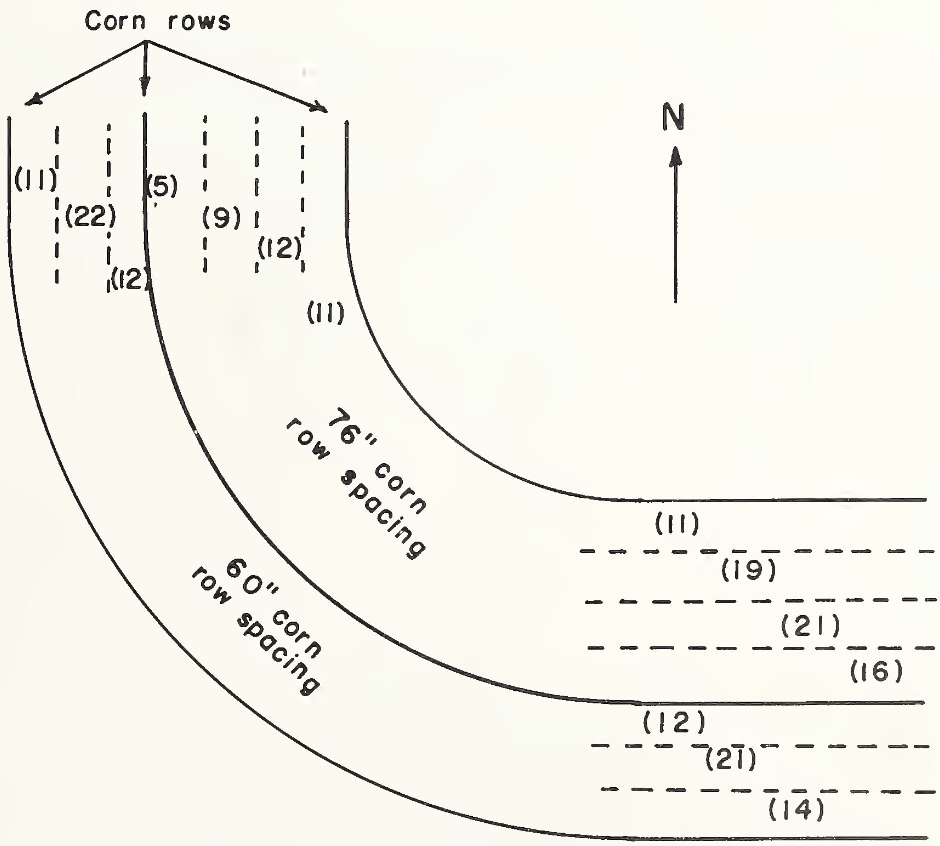
The observations and measurements were made on a field trial conducted in cooperation with a farmer in Lac qui Parle County. The interseeding was made June 30 in contoured-planted corn when 2 feet high.

Stands are less uniform in extremely wide corn rows as a portion of the interior spacing may be exposed to too much solar radiation.

In 1958 direction of corn rows seemed to have an influence on the stand of alfalfa when interseeded in 80-inch corn rows. As the contour rows approached an east-west direction, the northern part of the interrow seeding had a sparse stand. In 1959 with 76-inch corn rows alfalfa stands were satisfactory in the northern part of the interrow spacing. (See figure.)

Similar work in Wisconsin has shown that successful interseedings of alfalfa could be made in corn. The Minnesota trials indicate that the practice may have wider application than previously thought.

Interseeding reduces erosion and eliminates the need for using low-return, small grain nurse crops. (V-A-1)



Effect of row direction on Alfalfa plants per square foot between corn rows, - Lac qui Parle County, Minn., 1959.

Wisconsin

NEW CROPPING SYSTEM FOR THE UPPER MISSISSIPPI VALLEY

O. E. Hays, LaCrosse.--A hay crop, a corn crop, and an established new seeding all in the same year and on the same land offers a revolutionary, new type of cropping system for use in Northern States. Several years' results at LaCrosse, Wisc., show that it can be done, and successfully. Not only is it possible to remove two crops in the corn year, but the land is protected almost continuously by a dense vegetative cover.

The hay is made during the second week in June. This hay is fine stemmed, therefore normally of better quality than when made at one-tenth bloom.

The average yield for the 4 years' measurements made was 1.7 tons per acre, as shown below:

Yields of hay before corn at LaCrosse, Wis.

Year	Tons, per acre
1954	1.47
1955	1.72
1956	1.72
1959	1.86
Average	1.69

As soon as the hay was removed the land was plowed and immediately planted to an 85- or 90-day maturity Wisconsin Hybrid. After the corn was 8 inches high, it was cultivated. When about 15 inches high, it was cultivated the second time and interseeded to alfalfa. The interseeding was done with a grain drill from which the center drill assembly was removed, so that a corn row could be straddled with a minimum of injury to the corn. Packing wheels on the back of the drill firmed the soil over the legume seeds.

Yield of corn was somewhat reduced by the late planting date and the early maturity hybrid as shown below:

Corn yields by planting date for a 6-year period at LaCrosse, Wis.

Year	About June 1 Bu. per acre	About June 15 Bu. per acre
1954	111.2	91.5
1955	71.2	58.2
1956	115.0	73.2
1957	98.0	69.8
1958	81.8	53.1
1959	101.2	88.7
Average	96.4	72.4

When corn was planted about June 1 (the normal planting time) and the hay plowed under as a green manure, an average of 96 bushels per acre was produced. When corn was planted about June 15 and the crop of hay was removed before the area was plowed, an average of 72 bushels per acre was produced.

This system is quite flexible under farm practice. The nearer to the normal time of corn planting, the better the corn yield. Delaying corn planting will reduce corn yields but increase hay yield. The farmer can vary the system somewhat to fit his needs.

The two-crop system is excellent for erosion control. The land is in hay until mid-June and therefore protected during spring and early summer rains. Wheeltrack planting effectively reduces runoff and erosion.

Interseeding legumes in the corn established a good cover by mid-August. Measurements show that the soil loss from this system is about one-fourth as much as those from a corn, grain, hay rotation. (V-A-I)

MOISTURE CONSERVATION

Iowa

SURFACE MULCH DECREASES CORN GROWTH IN NORTH-CENTRAL REGION

W. C. Burrows, Ames.--The early growth of corn in Iowa is reduced by surface residues applied at rates as small as 1 ton per acre, and is reduced still further by each increment added over 1 ton.

In a field experiment five rates of application of surface residues were used: 0, 1, 2, 4, and 8 tons per acre. In the table the relative growth of corn as affected by mulching rate is shown along with the average May-June soil temperature. The data show that each increment of mulch produced a decrease in height and weight of the plants and caused a lowering in soil temperature.

This study has produced additional evidence that the lowering in soil temperature caused by mulches is a primary factor in reducing the growth of corn where mulch tillage is used in the North-Central States. (V-B-1)

Growth of corn as related to mulch rate at Ames, Iowa, 1957

Rate	Relative growth		Average soil temperature (4"- depth)
	Height (51 days after planting)	Dry matter (49 days after planting)	
Tons			°*F.*
0	100	100	62.8
1	95.0	76.6	62.3
2	86.5	46.0	61.4
4	74.6	33.0	59.7
8	67.2	15.4	58.2

Nevada

EVAPOTRANSPIRATION OF NATIVE MEADOW TO BE STUDIED

Rhys Tovey and Victor I. Myers, Reno.--Nine lysimeters have been installed on the floodplain of the Humboldt River near Winnemucca, Nev., to study the evapotranspiration of native meadow vegetation under prevailing water table and climatic conditions. The site was selected to provide a natural climatic environment for the meadow vegetation in the tanks. These tank studies are a segment of a comprehensive research program being supported by numerous State and Federal agencies and coordinated by the Nevada State Department of Conservation and Natural Resources. The overall program is primarily concerned with developing data, techniques, and procedures which may be usable and valuable in measuring the land and water resources of the Humboldt River and in developing programs for their effective utilization.

The nine black vinyl plastic lysimeters were installed in October 1959 and filled with soil from the surrounding meadow. During the growing season of 1960 stands of meadow vegetation (sedges, bluestem, and saltgrass), transplanted while dormant, will be established in the lysimeters and their root systems allowed to develop under soil moisture conditions considered most ideal for optimum plant growth. Measurements of the consumptive use rates of the meadow grasses established in the lysimeters will begin in the

spring of 1961. The water tables in the lysimeters will be maintained at the same level as that in the adjacent meadow while measurements are being taken.

The basic instrumentation for the installation will be a class A weather station. Plans also call for a net-exchange radiometer to measure the energy of incoming and out-going radiation, thermocouples to measure soil temperatures, anemometers to determine wind profiles, black and white atmometer bulbs to measure evaporation, and a dual water-stage recorder to keep a continuous record of the water level in the lysimeters and in the adjacent meadow.

The extensive evapotranspiration and weather data gathered at Winnemucca along with more limited data gathered at other locations on the Humboldt will provide basic information for determining the use of water by meadow vegetation throughout most of the Humboldt Basin. (I-B-6 and II-A-1)

New York

WOOD CHIP TOPDRESSINGS BENEFICIAL IN NORTHEAST

G. R. Free, Ithaca.--Long term studies on Honeoye silt loam at Marcellus, N. Y., show that annual wood chip topdressings improve yields of several vegetable crops.

An experiment was started in 1951 using a 5-year rotation of sweet corn, dry beans, tomatoes, late cabbage, and peas with clover seeding, with and without wood chips. The wood chip treatment consisted of an annual topdressing of 7 tons per acre (dry weight) of a mixture of elm, maple, and ash chips, made immediately after planting. The per-acre rates of N, P_2O_5, and K_2O applied to the different crops were: Sweet corn, 30-60-30; dry beans, 30-60-30; tomatoes, 80-160-80; cabbage, 100-200-100; and peas, 30-60-30. On half of the plots the fertilizer rates were reduced by one-fourth, and on some of the plots 100 pounds per acre of additional nitrogen were added. All crop residues were returned to the soil.

Results for the different crops at the high rate of fertilization are summarized below.

Harvested		Yield per acre	
Crop	Year	Without wood chips	With wood chips
		Tons	*Tons*
Sweet corn	1951	4.8	4.5
(in husks)	1956	6.6	5.1
Beans	1952	1.07	1.31
	1957	1.12	1.32
Tomatoes	1953	18.5	21.1
	1958	17.0	21.2
Cabbage	1954	15.6	21.1
	1959	18.7	24.1
Peas	1955	2.0	2.32

These data show that sweet corn was the only crop that did not benefit from wood chips. Excluding the corn, wood chips resulted in an average increase in yield of 23 percent. The decrease in yield of the sweet corn may be related to the lowering of soil temperatures in the spring. This has been verified for field corn in Iowa and elsewhere.

Differences between fertilizer treatments were small. Yields under the "one-fourth fertilizer" treatments, however, averaged about 20 percent less than yields under the corrresponding "full fertilizer" treatments and showed the importance of an adequate fertilizer level.

The beneficial effects of topdressed wood chips on yields probably can be attributed to: (1) Maintenance of good soil physical condition as evidenced by bulk density and aggregate stability tests, (2) the addition and conservation of plant nutrients, (3) conservation of moisture, and (4) reduction of high soil temperatures except for the corn where this is a detriment. A higher earthworm population (about four times higher than check) has been found under all wood chip treatments. Frost penetration in inhibited. Observational data also indicate reduced runoff and erosion.

Wood chips in most areas are not commercially available in quantity. It would seem, however, that woody residues from prunings and thinnings might be used with conservation benefits to producer as well as to user. (V-B-1)

North Dakota

CONSERVATION BENCHES CONSERVE WINTER PRECIPITATION

Howard J. Haas and G. O. Boatwright, Mandan.--Conservation benches may be an answer to the problem of conserving winter precipitation in the Northern Plains, if wheat yields obtained in 1959 are an indication. Level benches, 30-feet in width with an equal width contributing area, were constructed in 1957 on a silt loam with a slope ranging from 5 to 9 percent. The benches and wheat plots on the contributing area were uniformly cropped to spring wheat in 1958, and received 120 pounds of N and 80 pounds of P_2O_5 per acre. Various treatments were applied to the contributing areas in the fall of that year. The contributing area treatments were, as follows:

1. Impervious--plastic film over the contributing area.
2. Bromegrass on contributing area.
3. Spring wheat on contributing area--fall chiseled.
4. Spring wheat on contributing area--not chiseled.
5. No contributing area--foreign water diverted away from bench.

Sixty pounds of N and 40 pounds of P_2O_5 were applied to the wheat plots in the spring of 1959. Wheat grain yields obtained are presented in the accompanying table. Three areas were harvested across the bench. "A" was on the cut portion next to the contributing area, "B" in the middle of the bench, and "C" on the filled area at the outer edge of the bench. Three areas were also harvested on the contributing areas in wheat. "A" was at the upper end, "B" in the middle, and "C" at the lower end. Precipitation for the growing season was only 4.9 inches which was 4.6 inches below the long-time average.

The yield on the bench with an impervious contributing area was significantly higher than any other treatments, while there was no significant difference between the other yields on the bench. Yields from the harvest areas were generally highest on the filled area and lowest on the cut area with two exceptions. Wheat on the contributing area burned severely and averaged only 2.0 bushels per acre.

The data from the plots without a contributing area (water diverted) indicate that respectable yields can be obtained even in an extremely dry season if the land is leveled and diked to prevent runoff in the spring. It has been a common belief in the past that the benefits from winter precipitation are not great because of loss due to blowing snow and to runoff in the spring from frozen soil. The results from the bench study indicate that considerable benefit may be received if the snow is trapped and runoff is prevented when the snow melts in the spring. This may prove to be one of the main advantages of conservation benches in the Northern Plains. (IV-C-1, V-H-2)

Spring wheat yields per acre obtained on conservation benches with differently treated contributing areas and on the contributing area at Mandan, N. Dak., 1959.

Treatment	Harvest area A	Harvest area B	Harvest area C	Mean
On bench	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Impervious contributing area	29.0	25.2	22.4	25.5
Grass contributing area	14.4	21.9	19.4	18.6
Wheat contributing area--chiseled	12.3	14.5	19.9	15.6
Wheat contributing area--not chiseled	13.8	15.1	26.2	18.4
No contributing area--water diverted	13.5	17.4	18.3	16.4
Mean	16.6	18.8	21.2	18.9
On contributing area				
Fall chiseled--spring plowed	1.5	1.1	3.9	2.2
Not chiseled--spring plowed	2.4	1.6	1.2	1.7
Mean	2.0	1.4	2.6	2.0

North Dakota

PLASTIC MULCH INCREASES CORN YIELDS AND WATER USE EFFICIENCY

Joseph Alessi and Howard J. Haas, Mandan.--Plastic film, which either partially or completely covered the soil, increased corn yield and the moisture use efficiency by reducing evaporation losses and increasing soil temperatures.

The trial consisted of nine plots with three cover treatments (1) bare, (2) partial cover - strips of plastic film between rows, and (3) complete plastic cover. Each cover treatment had three levels of soil moisture (1) nonirrigated, (2) preplant irrigated, and (3) seasonal irrigated. Black polyethylene film (0.004 inch thick) was used.

Tassel emergence was 6 days earlier on the completely covered plots than on the bare plots. Amount of available water influenced final plant height. Greatest height was obtained on plots receiving seasonal irrigation followed by preplant irrigation and non-irrigation. Cover treatment, based on an average of the three moisture levels, influenced plant height in the following descending order: partial, bare, and complete cover.

Soil temperature (3" depth) was higher during the growing season in the completely covered plot than the bare plot. However, the greatest difference in temperature between covered and bare plots occurred early in the season when the black plastic film was fully exposed to the sun rays. As the corn plants developed and shaded the soil, temperature differences between the two treatments became less.

Partially covered treatment produced the highest corn yields (table 1) in the nonirrigated and preplant irrigated treatments. The partially covered treatment allowed rainfall to enter the soil, reduced evaporation, and increased soil temperatures. No rainfall entered the soil in the completely covered plots and the deficiency of moisture reduced yields in the nonirrigated and preplant irrigated treatments. With seasonal irrigation, highest yields were obtained from the completely covered plots particularly in the case of grain. Apparently, higher soil temperatures under the completely covered plot favored plant development and the release of nutrients in the soil.

TABLE 1.--Yield per acre of corn silage (70-percent moisture) and ears (15-percent moisture) produced from plastic mulch study, Mandan, N. Dak., 1958.

Soil covering	Moisture treatment		
	Nonirrigated	Preplant irrigated	Seasonal irrigated
SILAGE			
	Tons	*Tons*	*Tons*
Bare	4.82	7.65	15.38
Partial cover	8.23	9.29	17.29
Complete cover	3.77	5.96	17.52
GRAIN			
	Bushels	*Bushels*	*Bushels*
Bare	0.0	30.3	81.7
Partial cover	27.2	42.9	81.8
Complete cover	0.7	17.0	94.0

Water use efficiency data presented in table 2 indicate that as available water was increased in the root zone by seasonal or preplant irrigation, or by reducing evaporation loss, water use efficiency generally increased. The completely covered, nonirrigated plot had an extremely high silage production for the amount of moisture used (2.28 tons/acre-inch). Partial cover delayed initial wilting by 10 days, compared to the bare plot in the nonirrigated treatment. (II-A-1, 5; III-B-1)

TABLE 2.--Yield of corn silage and ear corn produced per inch of water used from plastic mulch study, Mandan, N. Dak., 1958.

Soil covering	Moisture treatment		
	Nonirrigated	Preplant irrigated	Seasonal irrigated
SILAGE			
	Tons	*Tons*	*Tons*
Bare	0.55	0.74	0.92
Partial cover	.75	.87	1.11
Complete cover	2.28	1.30	1.43
EAR CORN			
	Bushels	*Bushels*	*Bushels*
Bare	0	2.9	4.9
Partial cover	2.5	4.0	5.2
Complete cover	0.4	3.7	7.7

PLASTIC MULCHES INCREASE EARLY GROWTH AND GRAIN SORGHUM PRODUCTION

J. E. Adams and D. O. Thompson, Temple.--Spring-planted crops in this area are frequently characterized by very slow growth during the first 6 weeks of the growing season. This slow early growth has been attributed to cool soil and air temperatures. Exploratory studies at Temple in 1958 with black plastic mulch on grain sorghum plots indicated that plastic mulch increased both water use efficiency and soil temperature. Plastic mulch studies with grain sorghum were continued in 1959 using both clear and black polyethylene film.

The spring months of the 1959 growing season were typical and seed zone temperatures in bare soil remained cool through most of April. Soil temperatures under the clear plastic mulch increased 5° to 6° F. at the 12-inch depth and 9° to 12° F. at the 3-inch depth during the first 10 days. Black plastic had no effect on soil temperature at the 12-inch depth, and the soil was slightly cooler than bare soil at the 1-inch depth during the same period.

Seedling emergence, growth rate, and plant development were faster with clear plastic mulches (table 1). The order of treatments with respect to yield of grain and forage was clear plastic mulch > black plastic mulch > bare (table 2). Analysis of variance results showed a statistical difference in treatment effect on both grain and forage yield. Plots with a complete plastic mulch cover had higher grain yields than those with middles covered, but did not differ statistically. The main effect of the plastic mulches in 1959 was the increase in soil temperature during the early part of the growing season. The extra moisture conserved by the plastic mulch probably had no more effect than supplemental irrigation which showed no response. (II-A-1, 5; III-B-1)

TABLE 1.--Sorghum (RS-610) plant height on plots with clear and black plastic mulch, Temple, Tex., 1959.

Date	Clear		Black		
	Complete cover	Middles covered	Complete cover	Middles covered	Bare
	Inches	*Inches*	*Inches*	*Inches*	*Inches*
April 6	6.4	5.8	4.7	4.3	4.4
April 20	12.0	9.2	6.8	7.3	6.0
May 1	27.8	19.5	14.7	15.6	11.9
May 13	44.2	39.1	32.1	32.6	27.2
July 27 (top of head)	59.7	60.4	59.7	59.3	56.1

TABLE 2.--Comparison of sorghum forage and grain yields harvested July 28, 1959 from plots with clear and black polyethylene film soil covers. Grain yield corrected to 13-percent moisture.

Treatment	Grain		Forage	
	Yield	Moisture content	Oven-dried weight	Moisture content
	Cwt/A	*Percent*	*1,000 lbs/A*	*Percent*
Clear-Complete cover.............	73.4	14.5	9.80	62.6
Clear-Middles covered............	71.9	14.7	9.40	60.8
Black-Complete cover.............	69.8	14.7	8.74	64.1
Black-Middles covered............	69.1	14.5	8.93	60.7
Bare.............................	62.5	15.1	7.28	61.5
LSD..............................	4.34	--	1.55	--

Texas

STUBBLE-MULCH TILLAGE STORES MORE WATER

Harold V. Eck, J. J. Bond, and Carl Fanning, Bushland.--When conditions are favorable for appreciable soil moisture storage, more water is stored under stubble-mulch tillage than under oneway tillage.

Available soil moisture at wheat seeding time under oneway and stubble-mulch tillage is presented in the accompanying table. The data were collected on the continuous wheat plots at the Southwestern Great Plains Field Station.

Available soil moisture at seeding with oneway and stubble-mulch tillage.

Year	Continuous wheat	
	Oneway tillage	Stubble mulch tillage
	Inches	*Inches*
1943..................................	0.7	0.9
1944..................................	2.9	2.2
1948..................................	1.4	0.7
1949..................................	2.4	3.4
1950..................................	3.3	5.1
1954..................................	0.1	0.2
1955..................................	2.7	3.7
1956..................................	0.3	1.0
1958..................................	2.7	4.6
1959..................................	1.8	1.3
Average...............................	1.8	2.3

On the average for the 10 years, the stubble-mulched plots contained 0.5 inches more available water at seeding than the onewayed plots.

More comprehensive moisture and rainfall data show that the moisture differentials present at planting in the four seasons were established during periods of heavy rainfall.

1949: 2.79 inches of high intensity rainfall in November 1948 and heavy snowfall in January 1949.

1950: 18.13 inches of rainfall June 1 to October 1, 1950.

1955: 6.80 inches of rainfall August 1 to October 1, 1955.

1958: 7.79 inches of rainfall in July 1958.

In 1958 if all rainfall between harvest and planting is considered (9.88 inches), moisture storage efficiency under oneway tillage was 33 percent, while that under stubble-mulch tillage was 51 percent.

The greater soil moisture storage with stubble-mulch tillage has contributed to higher wheat yields. For the entire period of experimentation (1943-1959), continuous wheat yields with oneway and stubble-mulch tillage have averaged 8.6 and 10.1 bushels per acre, respectively. (V-B-1, 2)

Virginia

EFFECTS OF STRAW MULCH ON CORN PRODUCTION

J. E. Moody, J. Nick Jones, Jr., and J. H. Lillard, Blacksburg.--A straw mulch conserved soil moisture and materially increased corn yields during the relatively dry growing season of 1958.

The experiment was designed to study the effects of mulching on soil moisture, soil temperature, and plant growth. Wheat straw at the rate of 3 tons per acre placed on the soil surface was compared to the same amount plowed down. Prolonged wet weather conditions in May delayed planting until May 28. However, during the remainder of the growing season rainfall deficiencies greater than 1-inch were recorded for each month, as shown in the tabular matter below:

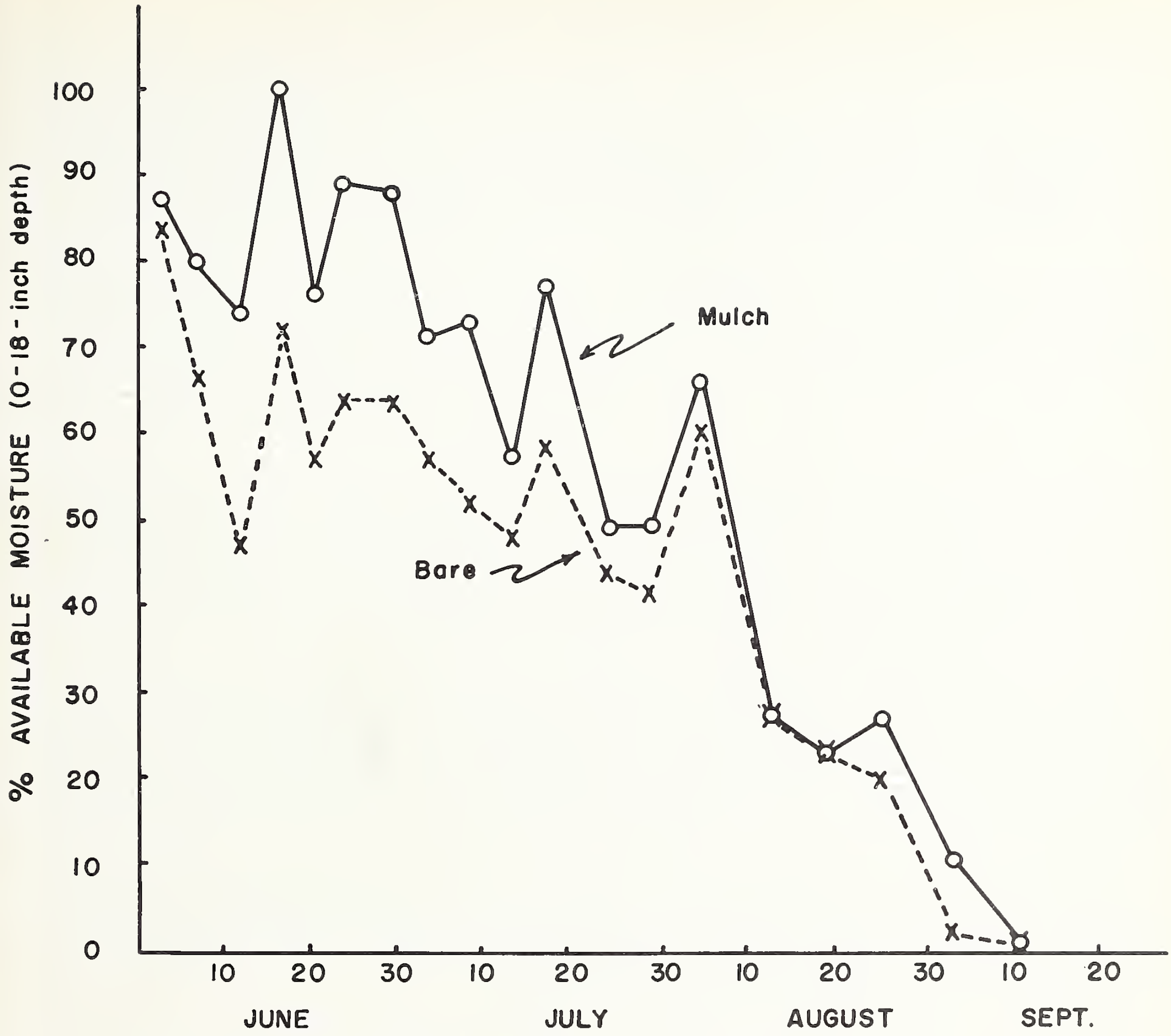
Monthly rainfall totals (May - Sept.) for 1958 and the 66-year average for Blacksburg, Va.

	May	June	July	Aug.	Sept.	Total
1958	5.82	2.93	2.70	2.43	1.94	15.82
66-Yr. Av.	4.52	4.25	4.89	3.83	2.96	23.58
Difference	+1.30	-1.32	-2.19	-1.40	-1.02	-7.76

The data on soil moisture as shown in the graph indicate that mulch was quite effective in reducing evaporation, particularly in June and July before the surface was shaded by the growing plants. Observations after rains indicated less movement of water on the surface and better infiltration under mulch conditions.

Corn grain yields where the straw mulch was placed on the surface averaged 105.2 bushels per acre, as compared to 81.9 bushels per acre when the straw was plowed down.

Although these heavy applications of mulch to corn under field conditions may not be practical, these data point out the effectiveness of surface mulch in conserving soil moisture during dry periods. (V-B-1)



SOIL MOISTURE AS AFFECTED BY
A STRAW MULCH BLACKSBURG, VIRGINIA - 1958.

Wyoming

BURNING OF VEGETAL COVER DECREASED WATER-INTAKE RATES

Frank Rauzi, Laramie.--Water-intake studies conducted near Rosalia, Butler County, Kans., on native pastures showed that burning of vegetal cover in the spring decreased the rate of water-intake.

During late October 1959, water-intake tests were conducted using a mobile infiltrometer on a pasture burned in the spring of 1959 and a pasture burned in the spring of 1954. Areas that appeared to have been heavily and lightly grazed were available in each pasture. In order to evaluate the effect of cover on the rate of water-intake within these pastures, three tests were conducted on lightly grazed areas and three tests on the heavily grazed areas. The area is in the 30- to 35-inch rainfall belt. The soil surface texture is silty clay loam.

During the period September 18 to October 13, 1959 between 9 and 10 inches of precipitation fell in this area. The soil moisture level at the time of test at this location was estimated to be near field capacity.

The accompanying table shows that the highest rate of water-intake occurred during the first 15-minute period of the 1-hour test. Thereafter, the rate of water-intake fell rapidly for the remainder of the test period on all treatments. It is assumed that interception by the standing vegetation and mulch material contributed to the high rates of water-intake during the first 15-minute period of the 1-hour test.

Data were analyzed to determine if significant differences in the rate of water-intake existed among treatments, for the first 15-minute period, first 30-minute period, second 30-minute period, and total for the 1-hour test. The analysis showed that the rate of water-intake was significantly higher for the lightly grazed plots on the pasture burned in 1954, than for all other treatments and periods, except the second 30-minute period of the 1-hour test which showed no significant differences in the rate of water-intake between treatments.

Dominant species on both pastures were big bluestem and little bluestem, with some switchgrass and side-oats grama. Even though the pasture burned in the spring of 1954 was harvested for grass seed 1 or 2 weeks before the tests were made, there was almost twice as much standing vegetation on the lightly grazed plots as on the lightly grazed plots on the pasture burned in the spring of 1959. Negligible differences were found in the amount of standing vegetation between the two heavily grazed areas. Apparently, some of the differences in standing vegetation between the two pastures may be attributed to the burning in the spring of 1959.

There was almost three times as much mulch material on the lightly grazed test plots on the pasture burned in the spring of 1954, than was present on the lightly grazed plots on the pasture burned in the spring of 1959. The heavily grazed plots on the pasture burned in 1954 had over twice as much mulch material present as the plots on the pasture burned in 1959. The loss of mulch by burning exposes the soil not only to erosion, but may also increase the rate of evaporation.

The effect of high soil-moisture content at the time of test decreased the rate of water-intake and masked the effect of cover. These data show that pasture burning in the spring significantly decreases the rate of water-intake during the 1-hour test on the lightly grazed plots, but no differences in the rate of water-intake was found for the closely grazed plots regardless of burning. (VI-A-1)

Water-Intake rates and standing vegetation and mulch per acre for lightly and heavily grazed areas of pastures burned in the springs of 1954 and 1959.

Spring burned	Grazed	Water-intake rate in 15-min. intervals				Total water-intake 1-hour[1]	Air-dried	
		1st	2nd	3rd	4th		Forage	Mulch
		Inches/ Hour	*Inches/ Hour*	*Inches/ Hour*	*Inches/ Hour*	*Inches*	*Pounds*	*Pounds*
1954..............	Lightly	1.92	0.56	0.20	0.08	0.69	5,150	2,627
1954..............	Heavily	1.36	0.28	0.16	0.08	0.43	1,376	1,808
1959..............	Lightly	1.36	0.40	0.24	0.16	0.54	3,174	943
1959..............	Heavily	1.20	0.40	0.28	0.20	0.53	1,577	831

[1] LSD (.05) level 0.15

Florida

MOISTURE-TENSION DATA FACILITATE DRAIN SPACING

H. A. Weaver and W. H. Speir, Fort Lauderdale.--Desorption moisture-tension data have been used to determine quantities of water released from a shallow, initially saturated, organic soil as changes in water table level occur. The water table drawdown time through small layers of soil has been found by dividing release values by the steady-state drainage rate corresponding to the average position of the water table in each layer. Total drawdown time was approximated by summing the times for all small layers included in the drained profile. The layers must be taken small enough so that the water table relations with drainage rate and water release are approximately linear within them.

Water release values for successive 3-inch water table drops in Everglades peaty muck are given in tabular form below:

Water released from Everglades peaty muck for successive 3-inch water table drops with profile initially saturated.

Water table change .... inches	0-3	3-6	6-9	9-12	12-15	15-18	18-21	21-24
Water released .... inches	.09	.21	.33	.45	.48	.54	.66	.51
Accum. water released .... inches	.09	.30	.63	1.08	1.56	2.10	2.76	3.27

Total times required to lower water tables from the surface to 18- and 24-inch depths are given in table 1 for various spacings of closed and ditch drains. Drainage rates used in these calculations were obtained from the Visser nomographic and Colding ellipse solutions, respectively. In these applications a mole drain depth of 30 inches and penetration of ditches to an impermeable layer at 4 feet were assumed. Further assumptions were that closed drains discharged at atmospheric pressure and water level in ditches was at zero height at all times. Although these conditions are not strictly met in the field, their assumption provides a margin of safety in design.

TABLE 1.--Total water table drawdown time from ground surface to 18- and 24-inch depths for various spacings of closed and ditch drains in Everglades peaty muck estimated from water release and theoretical drainage rate data.

Spacing	Water table drawdown time[1]			
	Closed drains		Ditches	
	18"	24"	18"	24"
Feet	*Hours*	*Hours*	*Hours*	*Hours*
10..........	2.2	5.5	1.4	2.8
20..........	9.3	20.0	5.5	10.9
40..........	32.2	70.8	22.2	44.3
60..........	64.8	139.8	50.9	100.5

[1] Drainage rates based on horizontal hydraulic conductivity of 4.2 inches per hour.

Previous work in this area indicates that water tables should be lowered within 48 hours after flooding and that a minimum safe level is around 18 inches. Based on these considerations and the expedient nature of mole drain construction it appears that spacings of such drains should not exceed 40 feet. Ditch spacings should not exceed 60 feet where they are the sole means for water control.

The use of water release data for solution of drainage problems has special application to the Everglades region where it is impracticable, by steady-state design, to control water tables at the onset of the high intensity rains predominating here. (II-B-1, 2)

EARLY TILLAGE ON FALLOW IS ESSENTIAL FOR FALL MOISTURE

Truman Massee, St. Anthony.--The amount of seedbed moisture present when winter wheat is drilled is largely dependent on the amount of moisture present when fallowing is initiated in the spring. Moisture changes in the surface soil due to summer precipitation and subsequent drying are similar, whether on a relatively dry or moist soil. Even when precipitation is above normal the quantity of stored soil moisture within the effective root zone is decreased about 1.5 inches from early spring to fall.

Fallow preparation was initiated by sweep tillage on Tetonia silt loam when the moisture content in the surface foot was (1) near field capacity, (2) about one-half of field capacity, and (3) near the wilting point. Moisture samples were taken at each tillage date and on August 17, September 1, and September 16. The moisture content in the 3 to 6-inch soil depth interval is given in table 1 for the three initial tillage dates.

TABLE 1.--Moisture in 3 to 6-inch soil depth resulting from three dates of initiating fallow.

Surface moisture at initial tillage	Moisture content, 3 to 6-inch depth				
	At plowing time	6/23/59	8/17/59	9/1/59	9/16/59
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Near field capacity, 5/6/59........	18.9	17.3	13.3	16.0	13.6
About one-half of available moisture depleted, 6/9/59........	12.8	16.3	12.5	15.4	13.0
Near at wilting point, 6/23/59.....	8.9	8.9	5.1	7.7	7.5

Even though 1.10 inches of precipitation were received between 6/9/59 and 6/23/59, the plots on which plowing was delayed until 6/23/59 lost considerable moisture. The other two treatments resulted in a moisture gain during the same period. Near normal August and September rainfall failed to recharge the surface moisture when initial tillage was delayed until the surface soil moisture was near the wilting point.

When initial tillage was delayed until the surface soil had become dry, moisture storage, winter wheat stands, and winter wheat yields were adversely affected. A summary of the data for 2 years is present in table 2. The establishment of winter wheat is especially critical. If summer rainfall is below normal, surface soil moisture is sometimes inadequate even when initial tillage is done early in the spring. Any loss of surface moisture due to delayed initial tillage increases this risk. The 1959 yield of winter wheat varied directly with stand with a significantly positive correlation coefficient of 0.81. (V-C-3)

TABLE 2.--The effect of initiating fallow at three dates on available moisture at planting time, stand, and yield of winter wheat.

Surface moisture at initial tillage	Total available moisture per 6 feet at planting time	Stand	Yield per acre of winter wheat
	Inches	*Percent*	*Bushels*
At field capacity, 5/6/59...............	6.48	95	27.3
One-half of available moisture depleted, 6/9/59................................	6.39	85	24.5
At wilting point, 6/23/59...............	5.69	55	19.0

Iowa

FALL OR EARLY SPRING PLOWING FOR WHEEL-TRACK PLANTING

W. E. Larson, Ames.--Wheel-track planting or similar form of minimum tillage works well on fall-plowed or early-spring plowed land if a cultivator or similar implement is mounted on the front of the tractor at the time of wheel-track planting. Usually wheel-track planting is done immediately after plowing, thus concentrating the work load in a short period of time.

In an experiment at Shenandoah, Iowa, in 1959 wheel-track planting was compared on fall plowed, early-spring plowed, and planting-time plowed land which had previously been in brome-alfalfa. On the fall-plowed and early-spring plowed treatments a cultivator was mounted on the front of the tractor at planting time. The results from these treatments and two check treatments are presented in the table.

Corn stand and yield per acre in wheel-track planting experiment

Treatment	Plants	Yield
	Number	*Bushels*
1. Fall plow, cultivate at planting, wheel-track plant..........	15,300	125
2. Early spring plow, cultivate at planting, wheel-track plant...	14,300	120
3. Early spring plow, double disk, harrow, surface plant without wheel-tracks..	14,500	122
4. Plow at planting, wheel-track plant.........................	12,400	110
5. Plow at planting, double disk, harrow, surface plant without wheel-tracks..	13,400	116

All yields were excellent. Late plowing, whether conventionally tilled or wheel-track planted, resulted in somewhat poorer stand and yield because of the extreme wet conditions at that time. The cultivating technique, together with wheel-track planting, is a once-over operation that kills weeds and breaks up the large clods resulting in excellent seedbeds. (V-C-3)

Kansas

SOIL COMPACTION INCREASES CLODDINESS POTENTIAL

Leon Lyles and N. P. Woodruff, Manhattan.--Laboratory results show that percentage of clods produced by chiseling of three soils containing 17 (sandy loam), 33 (silty clay loam), and 46 (clay) percent clay was increased by compacting to raise soil bulk density (figure 1). Total cloddiness after tillage was greatest on the clay, but rate of gain with increases in bulk density was more rapid for silty clay loam and sandy loam. For example, increasing the density from 70 to 80 percent of maximum raised the percent of clods greater than 6.4 mm. in diameter, 25 percent for silty clay loam and sandy loam as compared to about 14 percent for clay.

Breakdown by weathering was evident on all soils but to a greater degree on silty clay loam and sandy loam. More clods were still present at high density levels than low.

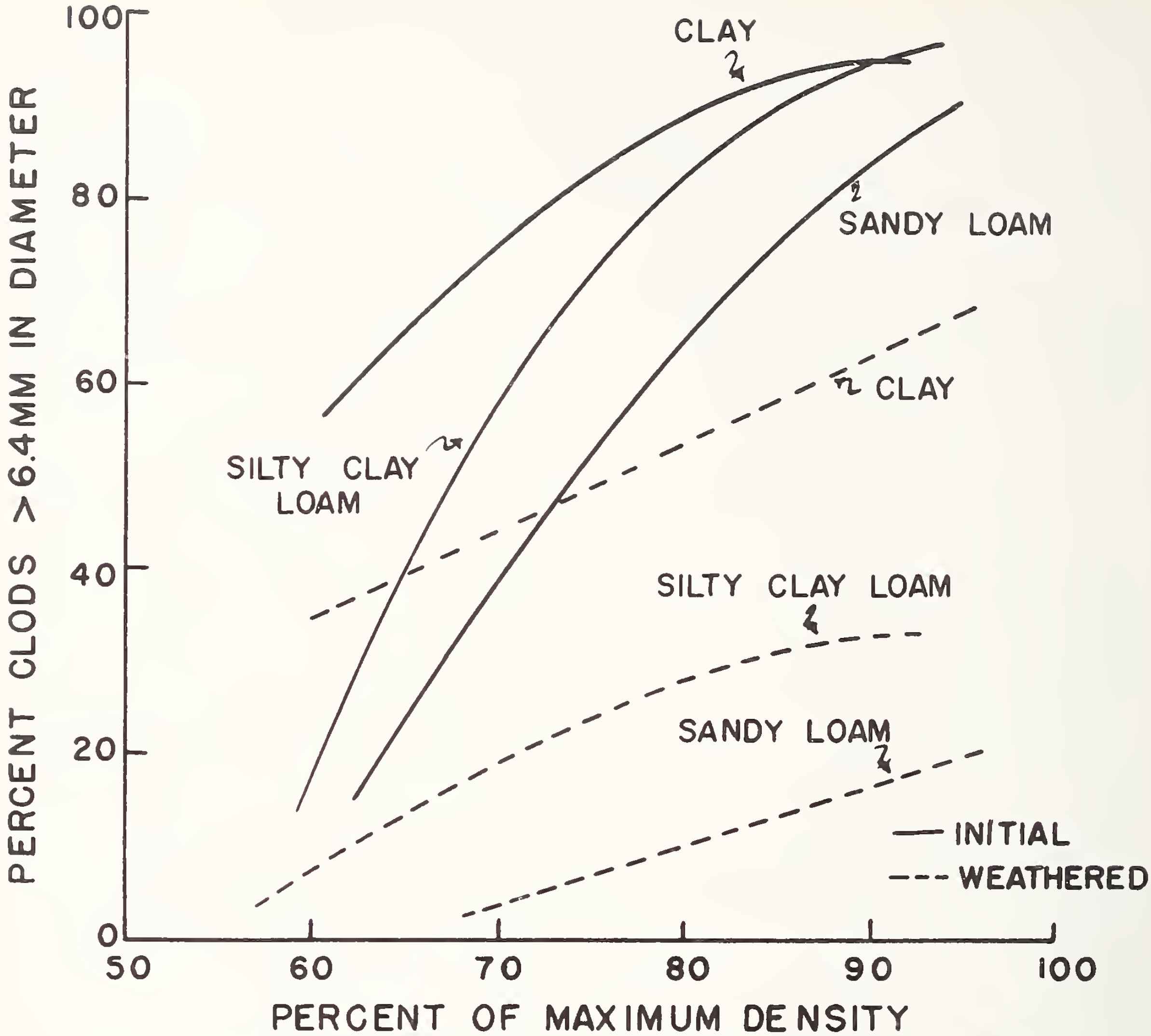


FIGURE 1. --Soil cloddiness immediately after chiseling and after 6 months of natural weathering in relation to soil density.

Crushing resistance of clods increased rapidly with drying if the soil had been packed to high bulk densities but rather slowly from lower levels (figure 2). The clay produced the strongest clods, and sandy loam the weakest.

Additional research is needed before making direct application of results to field conditions. However, on land susceptible to wind erosion it seems evident that packing before emergency tillage operations on fallow land or on land in the soil bank (which would allow packing when moisture conditions are favorable) might prove to be a very practical means of obtaining clods on soils that otherwise would produce few, if any, by tillage. (V-C-1)

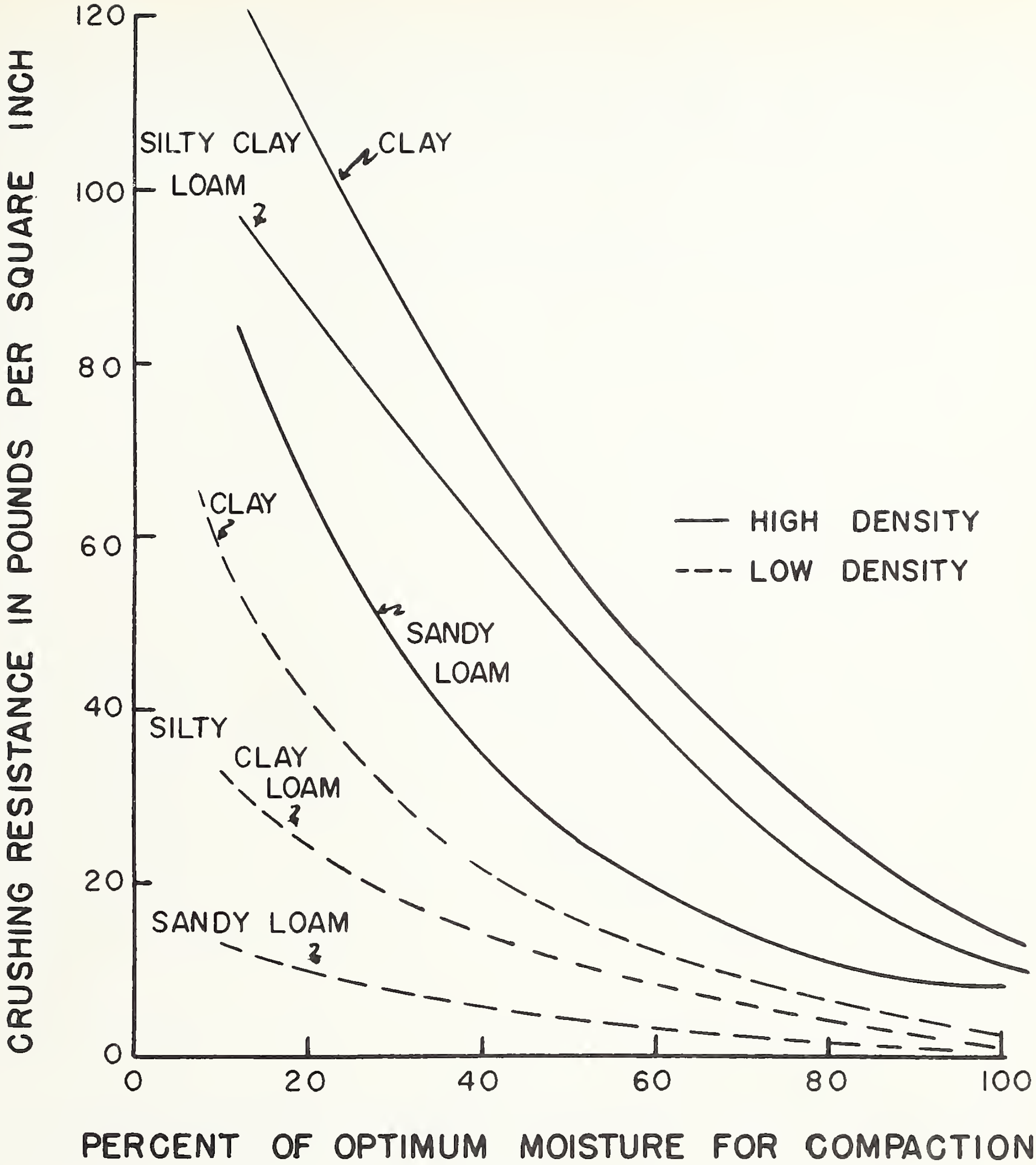


FIGURE 2. --Relationship between crushing resistance and clod moisture for soils packed to high (87 percent of maximum) and low (69 percent of maximum) bulk densities.

Minnesota

MOISTURE NOT RECHARGED IN WESTERN MINNESOTA, 1958-59

R. F. Holt, Morris.--Studies at the Morris Station indicate that a complete recharge of soil moisture did not take place from the end of one cropping season to the beginning of the next during the years of 1958 and 1959. Precipitation during the noncropping season of these years averaged 2 to 3 inches below normal.

The maximum available soil moisture for most of the soils investigated indicates that a good water supply for crops is possible. (See table.) Excluding evaporation a corn crop needs 8 to 10 inches of water to produce a satisfactory yield in this area. If the soils are completely recharged at the start of the growing season, a good crop should be assured. Complete recharge probably occurs only in years when precipitation is well above normal. Data in the table would indicate that full recharge would not occur most years. (II-A-1)

Maximum inches of available water in 5-foot profiles and percent of maximum available water present for representative soils in western Minnesota during 1958 and 1959.

Classification	Soil series	Max. avail. water[1]		
		5-foot profile	Spring '58	Spring '59
		Inches	*Percent*	*Percent*
Humic Gley...............	Fargo clay Wilkin Co.	13.84	51	32
Chernozem................	Aasted Silty clay loam Chippewa Co.	15.80	62	47
Chernozem................	Barnes clay loam Otter Tail Co.	13.27	66	51
Chernozem................	Rothsay silt loam Lac qui Parle Co.	13.53	76	65
Lacustrine Silts.........	Bearden silt loam Wilkin Co.	13.24	92	88
Degraded Chernozem.......	Waukon clay loam Otter Tail Co.	11.58	61	51
Chernozem................	Moody silt loam Rock Co.	13.35	64	54
Chernozem................	Vienna silty clay loam - Nobles Co.	10.79	57	12

[1] 1/3 atmosphere--15 atmospheres

Montana

SUBSOILING CLAYPAN SOIL HAS LITTLE EFFECT

Paul L. Brown, Bozeman.--Subsoiling a solodized-solonetz Post soil showed little effect on water penetration or oat yields in 1959. Vertical mulching with sawdust acted as a water reservoir and gave some indication of increasing yields.

Post soils are imperfectly drained soils occurring in the glaciated intermountain areas of western Montana. Noncultivated Post soils have a comparatively mellow surface soil. At a depth ranging from 6 to 12 inches, dull-brown, massive or columnar clay is present. In its extreme development the clay layer is 10- to 12-inches thick.

When irrigated, the infiltration rate is very low and the number of irrigations required is excessive. There are some indications that normal irrigation seldom wets the root zone more than 2 to 3 feet. Under dryland conditions these soils are inefficient in water storage because of their low infiltration rate.

The area was subsoiled in the fall of 1958 when the soil was dry following a red clover seed crop. The seedbed was prepared, border dikes formed, and oats seeded

without fertilization in 1959. $NaHCO_3$-soluble P_2O_5 in the surface soil was high, averaging 68 pounds per acre. Nitrogen was not added because of the previous clover crop.

Because of an unusually wet season the oats were irrigated only once. Times for the irrigation water to reach the ends of the treatment plots differed only slightly. If subsoiling had been effective in increasing total water penetration, times for water to reach the ends of the subsoiled plots would have been increased.

Moisture penetration was measured with a soil moisture probe. Soil tube sampling was impossible because buried glaciated boulders damaged the soil tube points. An average of about two probings per location was necessary to measure moisture penetration because of the rocks.

Moisture depth following irrigation and oat yields for the various treatments are shown in the table below.

Moisture penetration depths 4 days after irrigation and oat yields on subsoiled Post soil, Lake County, Mont., 1959.

Treatment	Irrigation water penetration	Oat yields
	Inches	*Bu. per acre*
Check	23	90.7
Subsoil, 15 inches deep[1]	25	91.3
Subsoil with spinner, 15 inches deep[1]	24	92.3
Subsoil with spinner, 15 inches deep[1], vertical mulch	19	100.1
Road rip, 15 inches deep[2]	28	81.6
Road rip, 21 inches deep[2]	25	92.7
Mean	24	91.4

[1] Subsoiled at 24-inch intervals.
[2] Subsoiled at 36-inch intervals.

There were some differences in moisture penetration, but the differences are not considered significant.

Oat yields were apparently depressed by the 15-inch road ripping and increased by the vertical mulching. A possible explanation of the yield depression from the 15-inch road ripping is that this treatment brought considerably more clay to the surface than the other treatments. Some of this clay was still visible on the soil surface in its original blocky form 1 year after the tillage operation. It had not mellowed or broken down.

The increased oat yield from vertical mulching may have been due to the mulch-filled slot acting as a water reservoir. A trench was dug across the plot 4 days after irrigation. Two sawdust-filled trenches were located. The sawdust showed little sign of decomposition and was saturated with water. Almost immediately water started seeping from the sawdust-filled slots into the trench. Soil moisture samples were taken 6 inches beneath the slots and midway between the two slots at the same depth. The moisture content beneath the slots and midway between the slots was the same, rather dry and crumbly. From all indications it appears that the vertically mulched slots served as water reservoirs but had little effect on water movement downward from the slot. (V-C-2)

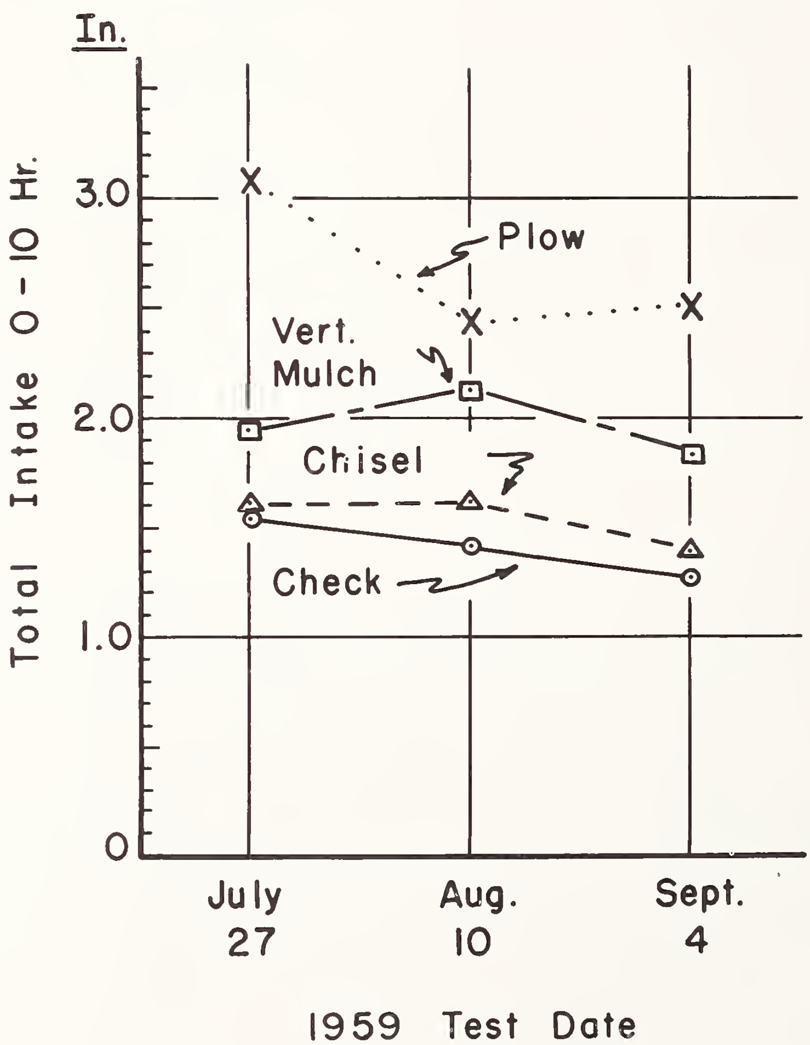
DEEP TILLAGE INCREASED WATER-INTAKE RATES

Victor L. Hauser and Howard M. Taylor, Bushland. --Disk plowing and vertical mulching 24-inches deep increased water-intake rate on Pullman silty clay loam during the first year after treatment.

A study of the effect of 3 deep tillage treatments on the intake rate was initiated in the spring of 1959. The treatments were chisel, vertical mulch, disk plow, and check (stubble-mulch tillage). All deep tillage treatments penetrated the top 24 inches of soil. The plots are 40 by 100 feet in size with a 30-foot buffer strip around each plot.

The yield of Hybrid RS 610 grain sorghum varied from 7,008 to 7,873 pounds per acre. Adequate fertilizer was applied to each plot to remove fertility variables and promote vigorous plant growth. To settle the tilled plots and wet the root zone, 10 inches of water were applied in March.

Intake rate was measured on three different dates during the growing season with FW-1 waterstage recorders. Intake records were made on July 27, August 10, and September 4, 1959. Total intake from time zero (end of 20-minute application period) to 10 hours is shown in the figure. The plow treatment was significantly better (5-percent level) than the other



Effect of tillage treatment on total water intake for 10 hours; Bushland, Tex., 1959

treatments on all dates. The vertical mulch treatment was significantly better than check and chisel treatments (5-percent level) on August 10 and better than check on September 4. The chisel treatment was not significantly different from the check on any date. (V-C-1, 2)

Texas

GRAIN SORGHUM YIELDS INCREASED BY DEEP TILLAGE

Victor L. Hauser and Howard M. Taylor, Bushland.--A study of three deep tillage treatments on Pullman silty clay loam soil was started in the spring of 1959. The treatments included are check (stubble-mulch tillage), chisel, vertical mulch, and disk plow. Each deep tillage treatment penetrated the top 24 inches of soil which, it was suspected, restricted water movement and plant growth.

Nitrogen and phosphorus fertilizers were applied at the rate of 240 pounds of N per acre and 265 pounds of P_2O_5 per acre to remove fertility as a variable. Twelve pounds per acre of hybrid RS 610 grain sorghum was planted in rows 20 inches on center. After plant emergence the plots received 24 inches of water in three 8-inch irrigations.

Grain yields are shown in the accompanying table. The treatment means are significant at the 1-percent level. The Duncan multiple range test indicated that the plowing treatment was significantly different from the other three treatments at the 5-percent level of probability, however, the check, chisel, and vertical mulch treatments were not different from each other at the 5-percent level.

The data indicate that plowing 24 inches deep, combined with adequate levels of fertility, increased irrigated grain sorghum yields on Pullman soil during the first year after tillage. (V-C-1, 2)

Grain sorghum yields from four tillage treatments at Bushland, Tex., 1959

Treatment	Yield
	Pounds per acre
Check	7,008
Chisel	7,015
Vertical Mulch	7,375
Plow	7,873

Washington

EFFECTS OF TRAFFIC AND COVER CROP ON SOIL COMPACTION

D. E. Miller and Wm. C. Bunger, Prosser.--An investigation of the degree to which normal traffic compacts the soil in a peach orchard of the Yakima Valley shows that the soil of areas subjected to equipment travel was more dense than that of the nontraveled areas. Most of the soil compaction occurred in the upper few centimeter of soil. As shown in figure 1, there was little difference in soil bulk density at a depth of 30 cm. between traveled and nontraveled areas. (These points are averages of all cover crops, and each point is an average of 36 individual samples.)

The different cover crop management practices used were continuous alfalfa, continuous orchardgrass, a winter cover crop of rye disked into the soil in the spring, and a surface maintained bare by chemical sprays. Bulk densities were measured in depth increments of 3 cm. to a depth of 30 cm. The effects of traffic were observed by comparison of the soil bulk densities in traveled areas to those in areas between trees where travel was minimum. The soil involved is classified as a Ritzville very fine sandy loam.

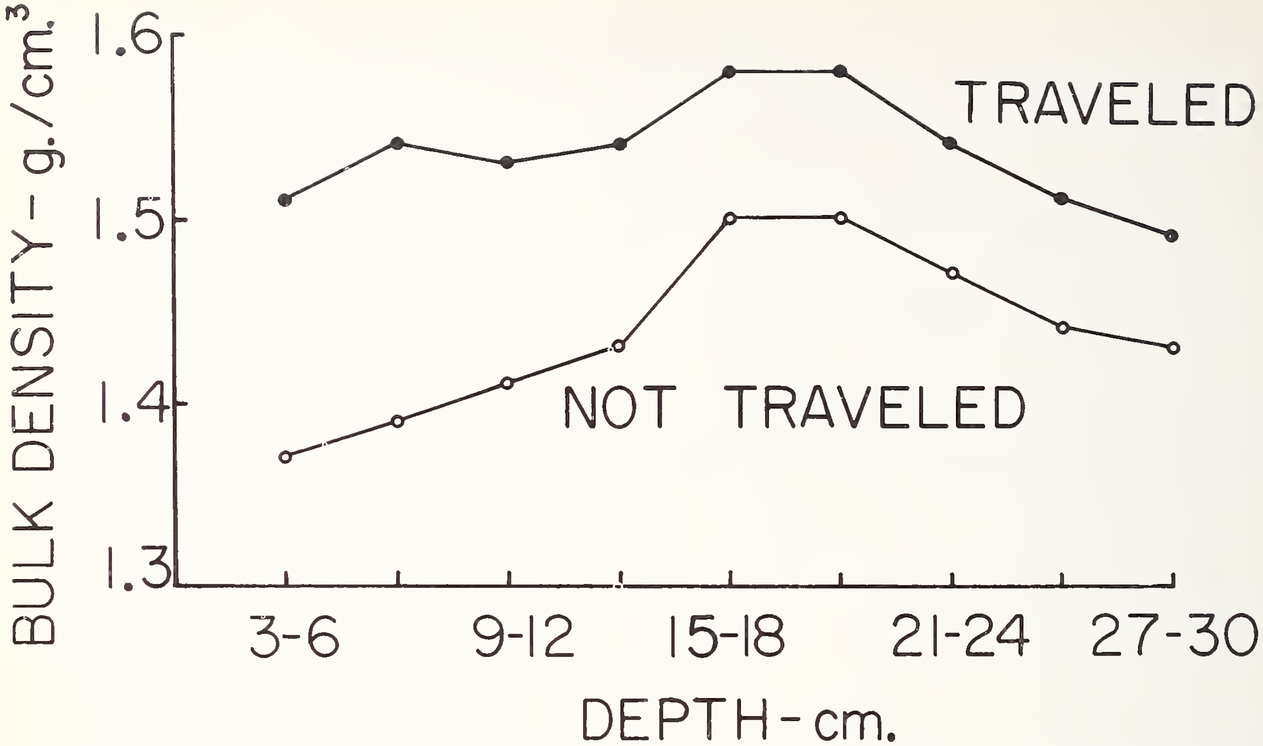


FIGURE 1. --Depth distribution of bulk densities as affected by travel. Curves are averages of four covers and each point is an average of 36 samples.

The degree of compaction with depth was influenced by the cover crop as shown in figure 2 (averages of traveled and nontraveled areas). The bare plot was compacted at the

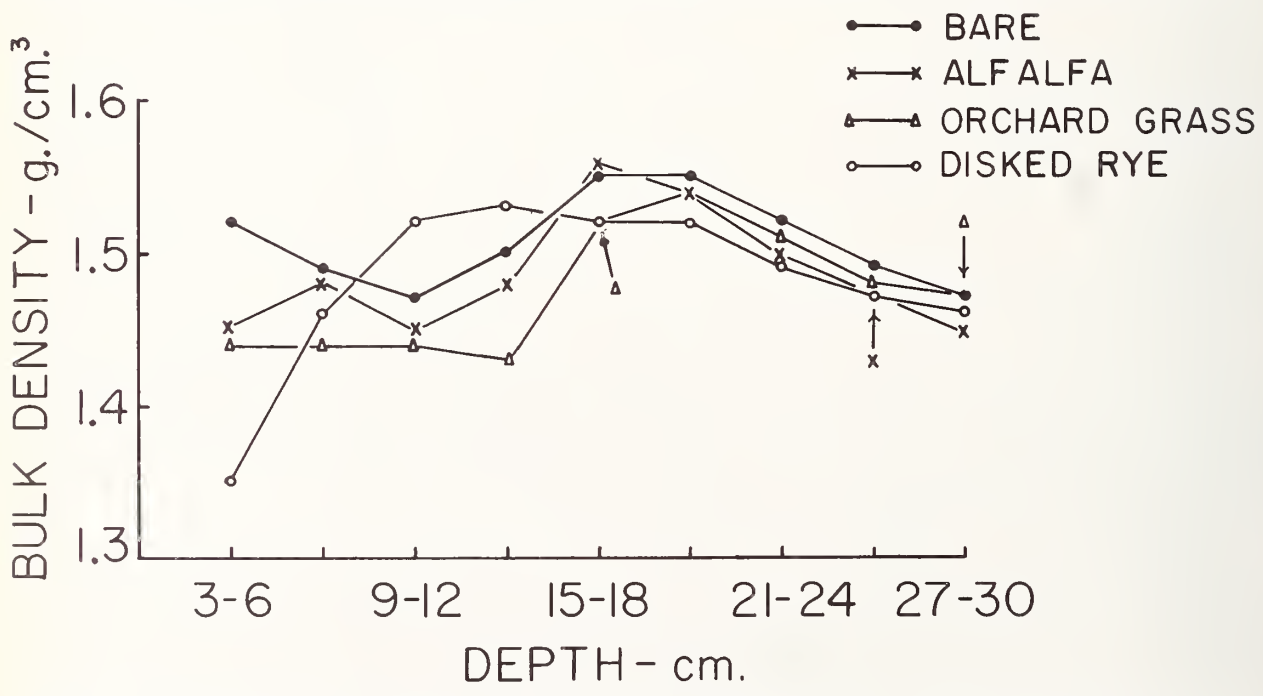


FIGURE 2. --Depth distribution of bulk densities as affected by cover. Curves are averages of traveled and nontraveled areas and each point is an average of 18 samples.

surface, and the degree of compaction at first decreased with depth to about 9 to 12 cm., then increased until the zone of maximum compaction was encountered. The disked areas were not compacted at the surface, but they became more dense with depth until the maximum was reached. The areas continuously in alfalfa and orchardgrass were somewhat intermediate between these two extremes, with the zone of maximum bulk density observed at depths ranging from 15 to 21 cm. among the various sites. There was little difference in density between the various covers at a depth of 30 cm.

The effect of travel on distribution of bulk densities with depth also varied among the various cover crops. The most obvious variation is shown in figure 3 in which it is observed that large differences existed in the surface between traveled and nontraveled areas seeded to alfalfa, while there was little difference in the disked areas. The variation due to travel for the areas seeded to orchardgrass or maintained bare was similar to that of the areas in alfalfa.

Stability of the 1 to 2 mm. aggregates in the 0- to 6-inch and 6- to 12-inch depths was determined by a wet-sieving procedure. Significant differences were not observed among cover crops, although the trend was for the bare surface to be least stable. Travel did not influence aggregate stability. The aggregates in the 6- to 12-inch depth were less stable than those in the 0- to 6-inch depth. The aggregation percentages were 35.2 and 50.1 respectively. (V-C-1)

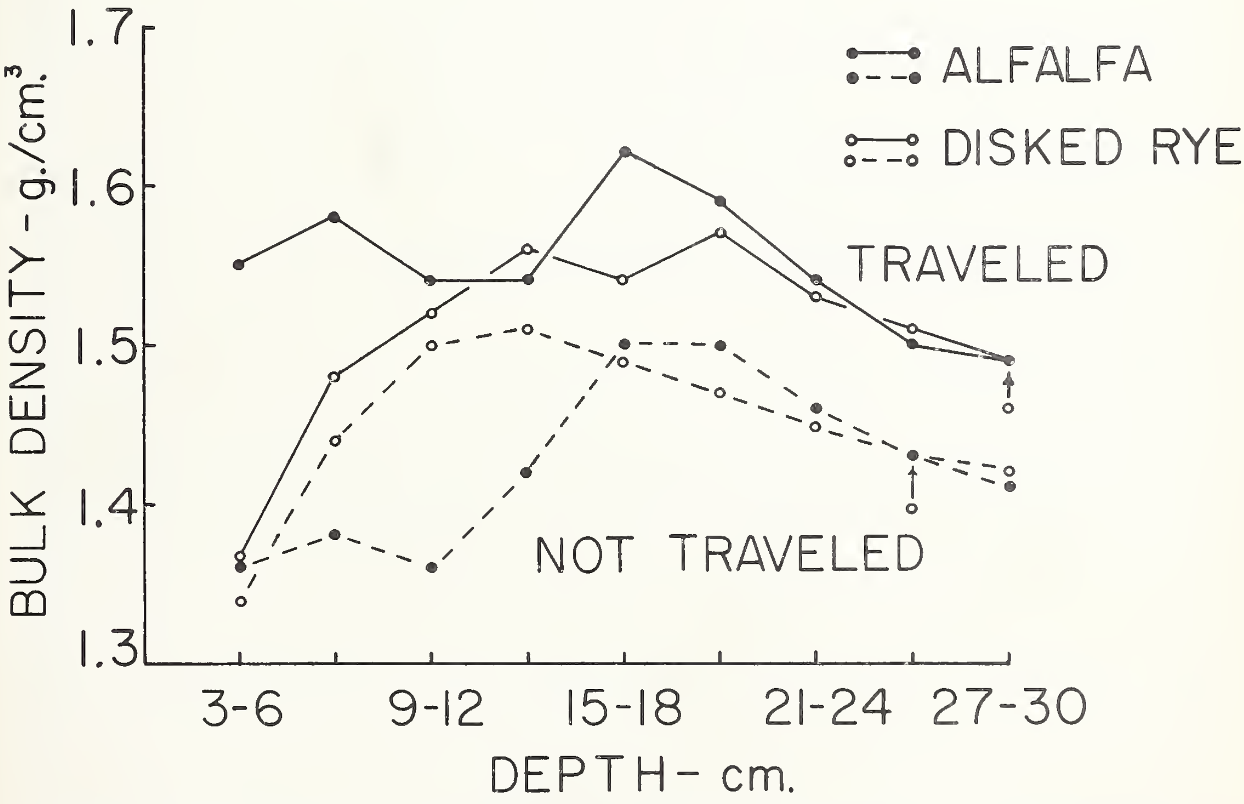


FIGURE 3. --Depth distribution of bulk densities as affected by cover and travel. Each point is an average of nine samples.

Wisconsin

CORN WHEEL-TRACK PLANTING MAY BE DELAYED AFTER PLOWING

Orville E. Hays and Robert E. Taylor, LaCrosse.--Two years' data on Fayette silt loam at LaCrosse suggest that it is not necessary to wheel-track plant on the same day the land is plowed. Plant populations and yields of corn were as high when planting was delayed 2 to 6 days as when the corn was planted the same day the land was plowed.

Treatments were established in three replications on hayland. The first year, 1958, was dry with only 1.1 inches of precipitation during May and 14.6 inches during the period of April 1 to October 31. In contrast 1959 was a year of high rainfall with 7 inches in May and 35 inches in the period of April 1 to October 31. (V-C-3)

Planting after plowing	Moisture 0-6"	Population plants per acre	Yield
1958:	*Percent*	*Number*	*Bu. per acre*
Same day	11.2	13,322	64.2
Two days	10.9	14,033	67.0
Four days	10.1	13,322	63.9
1959:			
Same day	23.9	11,669	96.4
Three days	19.4	12,544	101.4
Six days	20.0	13,229	92.3

SOIL AND WATER MANAGEMENT--GENERAL

California

EVAPOTRANSPIRATION IN SAN FRANCISCO BAY REGION

Dean C. Muckel, Berkeley.--A 5-year study to determine evaporation and evapotranspiration losses in the San Francisco Bay Region has been completed and a final report is now being prepared. This study, made at the request of the U.S. Army, Corps of Engineers, involved making an estimate of evaporation and evapotranspiration losses by months for the period 1921-22 to 1958-59, inclusive, for several salt water barrier plans in the San Francisco Bay system. Involved were 270,500 acres of free water surface and 35,000 acres of marshland.

Weather Bureau Class A pans were used as a basis for making the estimates. Twenty-five evaporation stations were located throughout the area. The average evaporation rates for specific subareas were obtained by the Thiessen Polygon Method. Two stations with long-time records were used to extend the records of the short-time stations to cover the desired 38-year period.

An important phase of the problem was that of determining proper coefficients by which Weather Bureau pan evaporation could be converted to evaporation from large lake surfaces and evapotranspiration from large areas of marshland by months. Conversion factors for evaporation were based on early work in southern California at Lakes Elsinore and Fullerton, at Lake Hefner in Oklahoma, and at Lake Mead on the Colorado River together with data collected at the Richmond Field Station of the San Francisco Bay study. Most of the evaporation pans operated in the San Francisco study were equipped with floating thermometers which provided valuable data for use in determining reduction coefficients.

Factors for converting Weather Bureau pan evaporation to evapotranspiration from marshland areas were based largely on data obtained at Joice Island in the San Francisco Bay region where a tank containing marshland vegetation was operated during the course of the study. This tank was set in the center of a large marshland area with an evaporation station nearby. Livingston atmometer bulbs were also located at several isolated places throughout the marshland.

The monthly factors finally arrived at for converting pan evaporation to lake evaporation and pan evaporation to evapotranspiration from marshland areas are shown in the table. These conversion factors are intended to apply only to coastal conditions.

The data indicate that evaporation and evapotranspiration losses vary less from year to year than any of the hydrologic factors going into a water supply study. Figure 1 shows the estimated annual evaporation and evapotranspiration losses for one of the salt water barrier plans for the period 1921-22 to 1958-59, inclusive. One of the most pretentious barrier plans would entail an average annual evaporation and evapotranspiration loss of 1,209,320 acre-feet. During the month of July a continuous flow of over 3,000 sec.-ft. would be required to satisfy the losses.

The average percent of annual evaporation and evapotranspiration from marshlands for each month is shown on figure 2. Again this applies only to coastal conditions as occur through the San Francisco Bay Region. (II-D)

Monthly reduction factors used to convert Weather Bureau pan evaporation to lake surface evaporation and evapotranspiration from marshland vegetation
(San Francisco Bay Region)

Month	Reduction factors converting Weather Bureau pan evaporation to:	
	Lake evaporation	Marshland evapotranspiration
October	0.80	0.80
November	.85	.55
December	.90	.65
January	.80	.60
February	.70	.35
March	.70	.45
April	.75	.65
May	.75	.70
June	.75	.80
July	.80	.85
August	.80	.95
September	.80	.80
Year	.78	.74

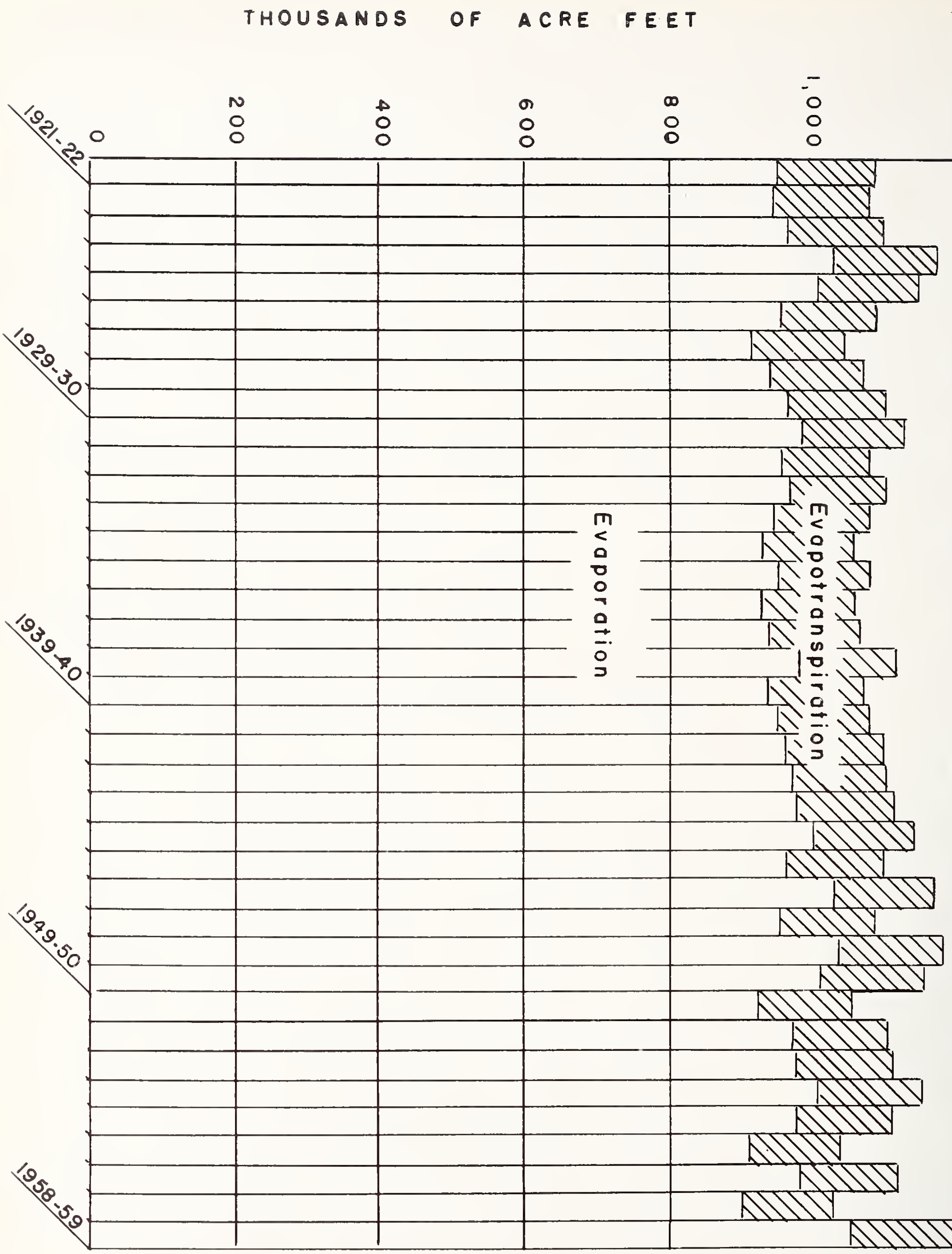


FIGURE 1. --Estimated annual evaporation and evapotransporation losses for one of the salt water barrier plans for the period 1921-22 to 1958-59, inclusive.

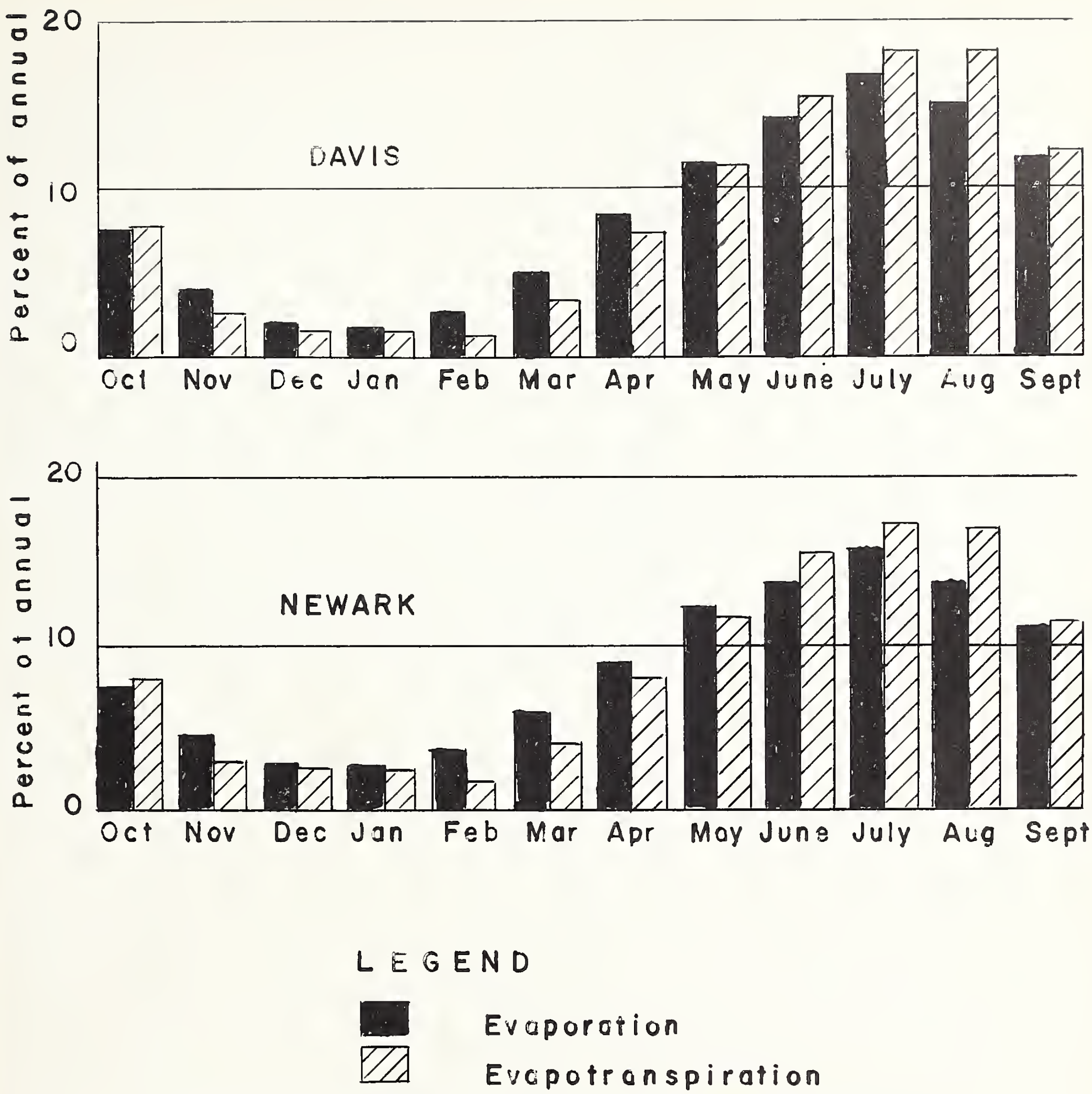


FIGURE 2. --Monthly variation of evaporation and evapotranspiration, Davis and Newark.

California

MIGRATION OF SOIL MOISTURE

Paul R. Nixon and G. Paul Lawless, Lompoc. --Downward movement of moisture in unsaturated soil profiles was observed using a neutron scattering moisture meter at numerous irrigated and nonirrigated sites in three hydrologic basins along the California coast. The downward migration of moisture was most striking in coarse-textured soils, although measurable translocation was observed in soils ranging to clay loam in texture. The amount of movement in the latter case was actually very small.

Moisture changes under a nonirrigated bare plot in sandy soil are illustrated by figure 1. Moisture content expressed as inches per inch can be converted to percent by volume by multiplying by 100. The sampling dates of the data illustrated by the figure are given in the accompanying table. Downward drainage by unsaturated flow of soil moisture

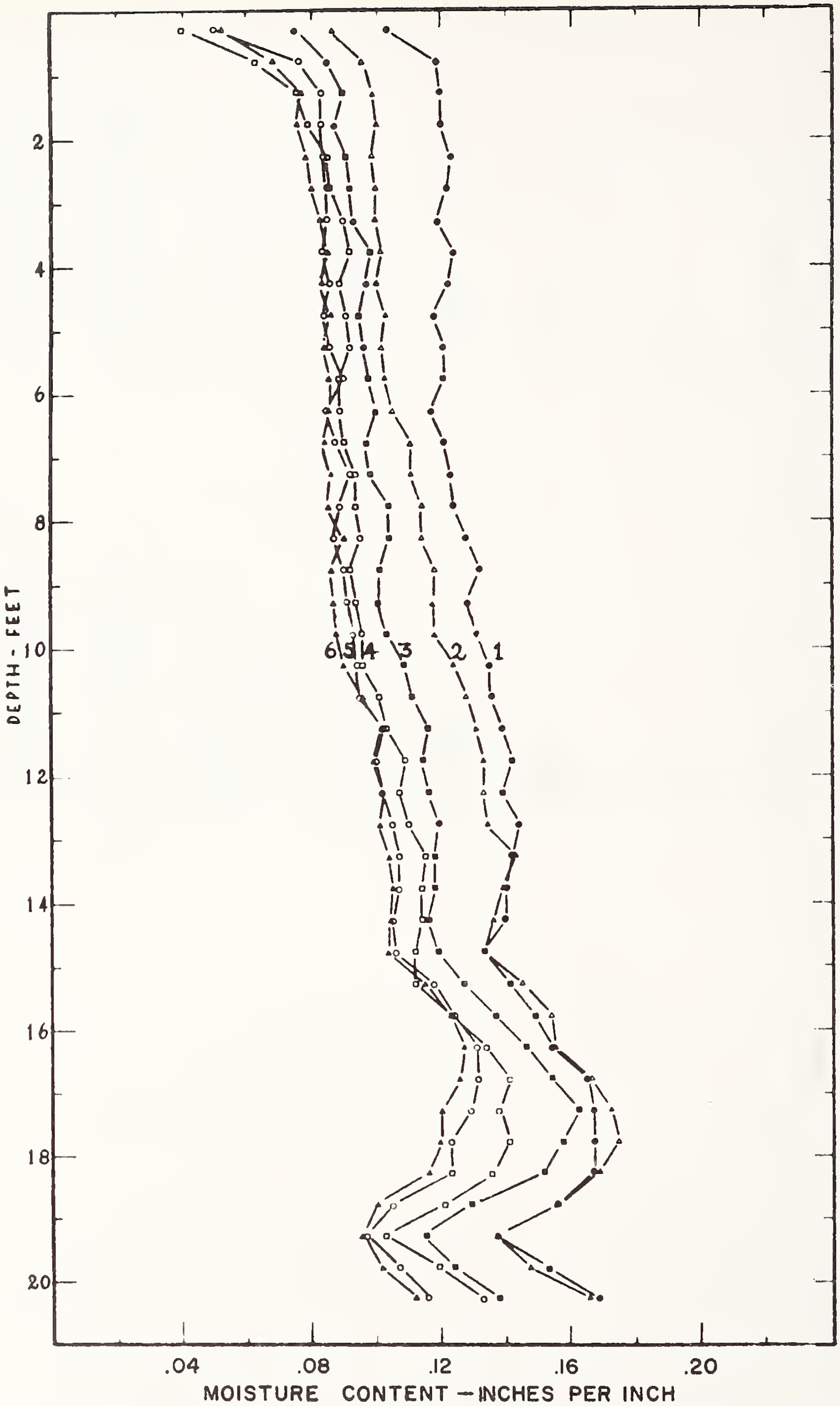


FIGURE 1. --Moisture depletion in Marina sand under a denuded plot.

Dates moisture was sampled in a denuded plot.

Sampling date	Curve
2/27	1
4/7	last rain
4/16	2
5/13	3
7/9	4
10/10	5
12/3	6

during a prolonged dry period is indicated by the parallel moisture profiles of the figure. Based upon limited tensiometer data, surface evaporation in this coarse-textured soil apparently removed appreciable moisture only from the surface 4 feet.

The same data, plotted on logarithmic scales as soil moisture contents against time, are shown in figure 2. The straight-line relations indicate that the rate of water loss for the various soil layers was proportional to water content and inversely proportional to the time since wetting.

This inability of soil to remain at a constant moisture content following wetting may be an advantage or disadvantage depending upon the situation. Some effects may be: downward transport of dissolved salts; ground water recharge; drainage problem due to rising water table; and loss of available moisture stored within the root zone. The magnitude of unsaturated flow may be quite insignificant in the case of fine-textured soils, while it can sometimes be a factor warranting consideration in coarser-textured soils. (III-B)

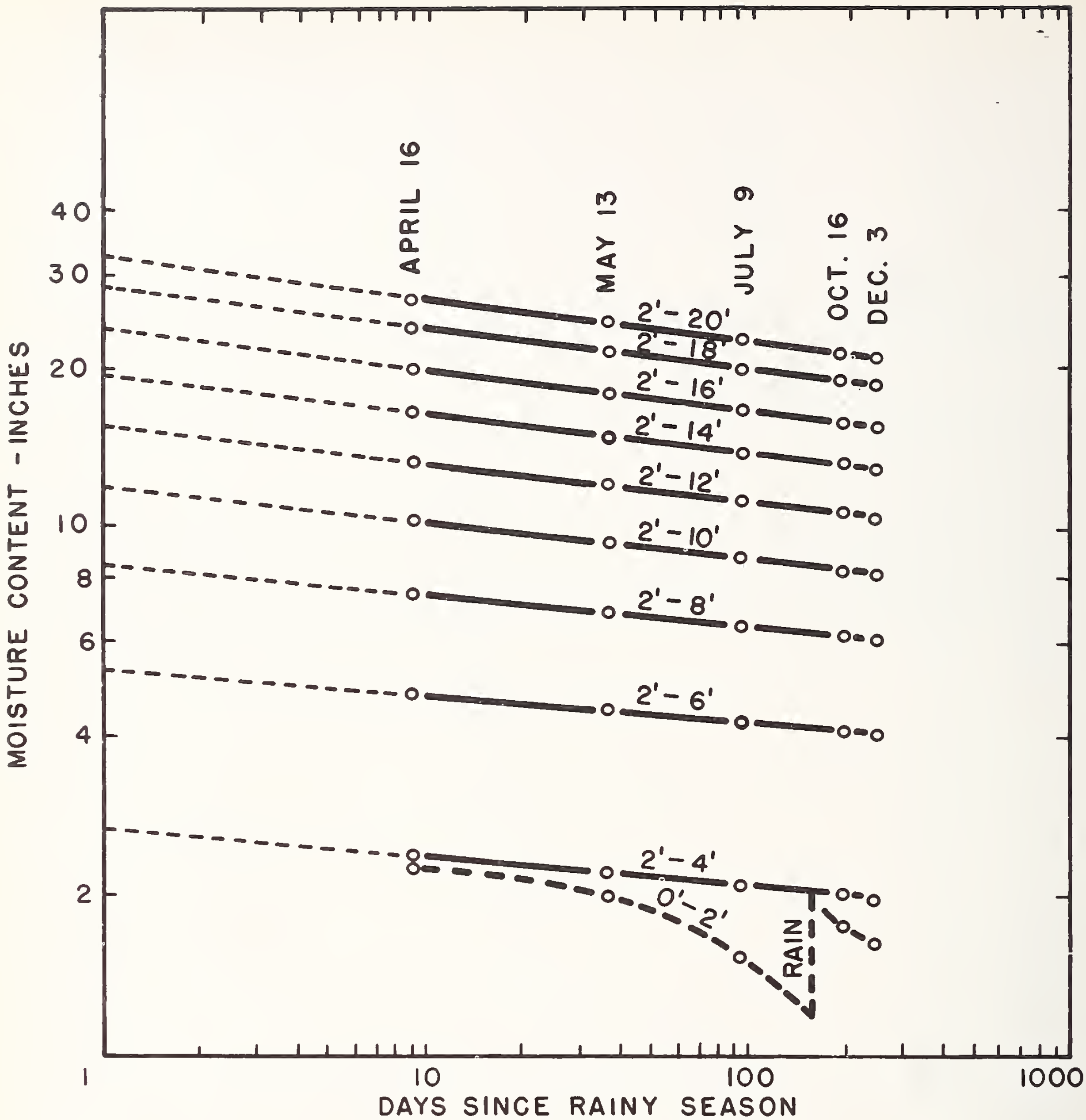


FIGURE 2. --Depth of water in various layers of marina sand under a denuded plot, 1958.

California

SOIL MOISTURE MEASUREMENTS USING NEUTRON METERS

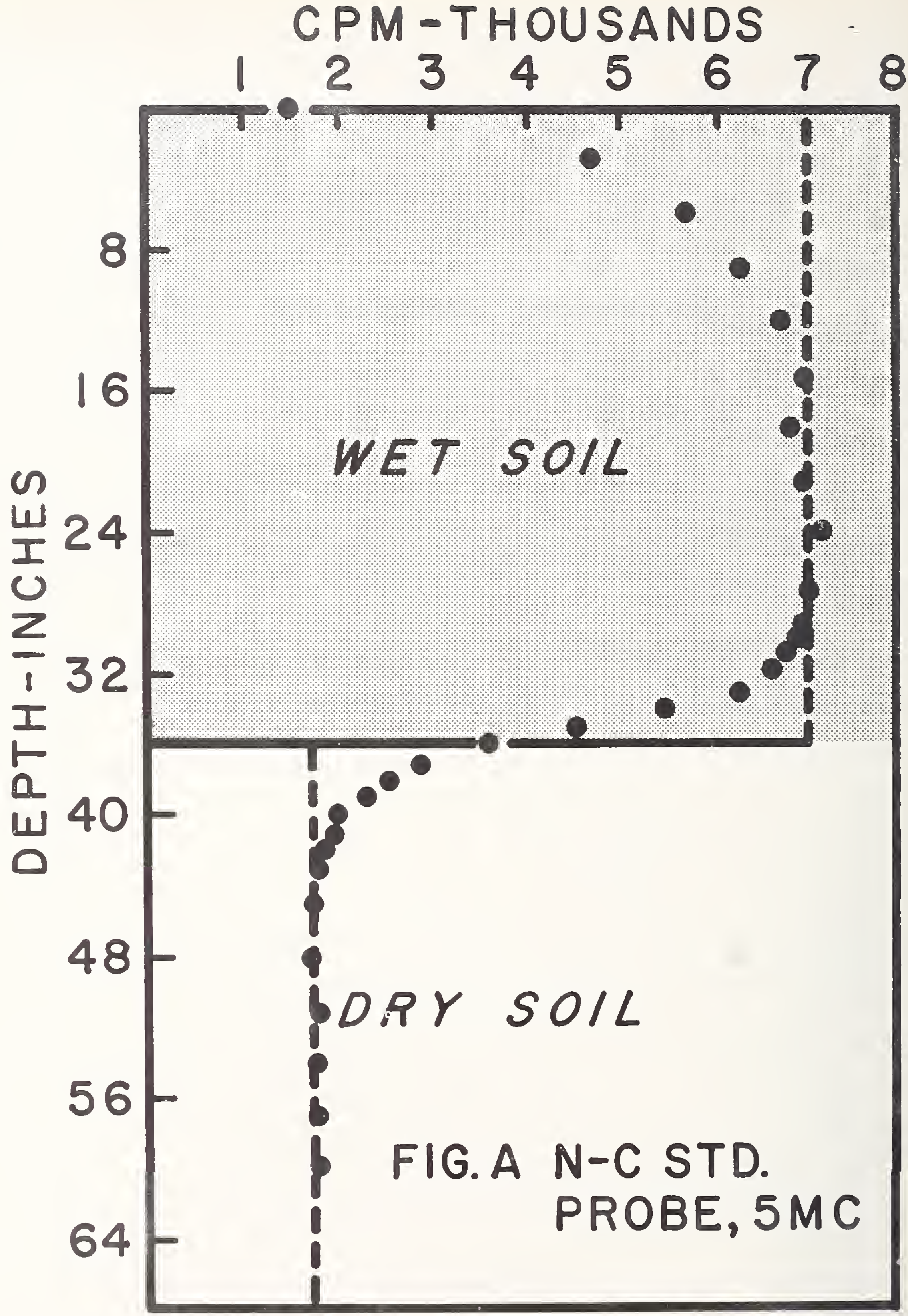
G. Paul Lawless, Norman A. MacGillivray, and Paul R. Nixon, Lompoc.--Soil moisture measurements can often be obtained more accurately in the field by the use of a neutron scattering moisture meter than by gravimetric sampling. Exceptions are measurements taken near the soil surface (air-soil interface) and near abrupt soil moisture changes (wet-dry interfaces).

An experiment was conducted in the field using moisture probes of four different designs at a site having a uniform profile of Marina sand. For this study layers of clay loam and sand were placed in pits 60 inches in diameter concentrically located about neutron meter access tubes. Examples of 1-minute readings (thousands of counts per minute) made with two of the probes are shown by dots on the accompanying figures. The vertical-dashed lines are estimates of unaffected count rates for the various layers.

It is obvious from the figures that the air-soil interface effect introduces serious errors to shallow readings taken with neutron depth probes. To overcome these errors other methods of moisture sampling should be employed, or at least the shallow neutron data should be improved by the use of correction coefficients.

The errors due to passing through wet-dry interfaces are somewhat compensating as illustrated in the figures. Although (at least in the cases of probe designs having the source located at midlength of the detector tube) moisture interfaces have the effect of biasing estimates of profile moisture content downward. The data also suggest that neutron readings are biased downward in the presence of moisture gradients, even though the gradients are uniform.

However, from the data collected it appears that the errors encountered within the soil mass may be neglected in many practical applications, particularly when small depth increments are used in making measurements and when one is interested mainly in knowing moisture changes from time to time. (III-B)


CPM-THOUSANDS
1 2 3 4 5 6 7 8
DEPTH-INCHES
8
16
24
32
40
48
56
64
WET SOIL
DRY SOIL
FIG. A N-C STD.
PROBE, 5MC

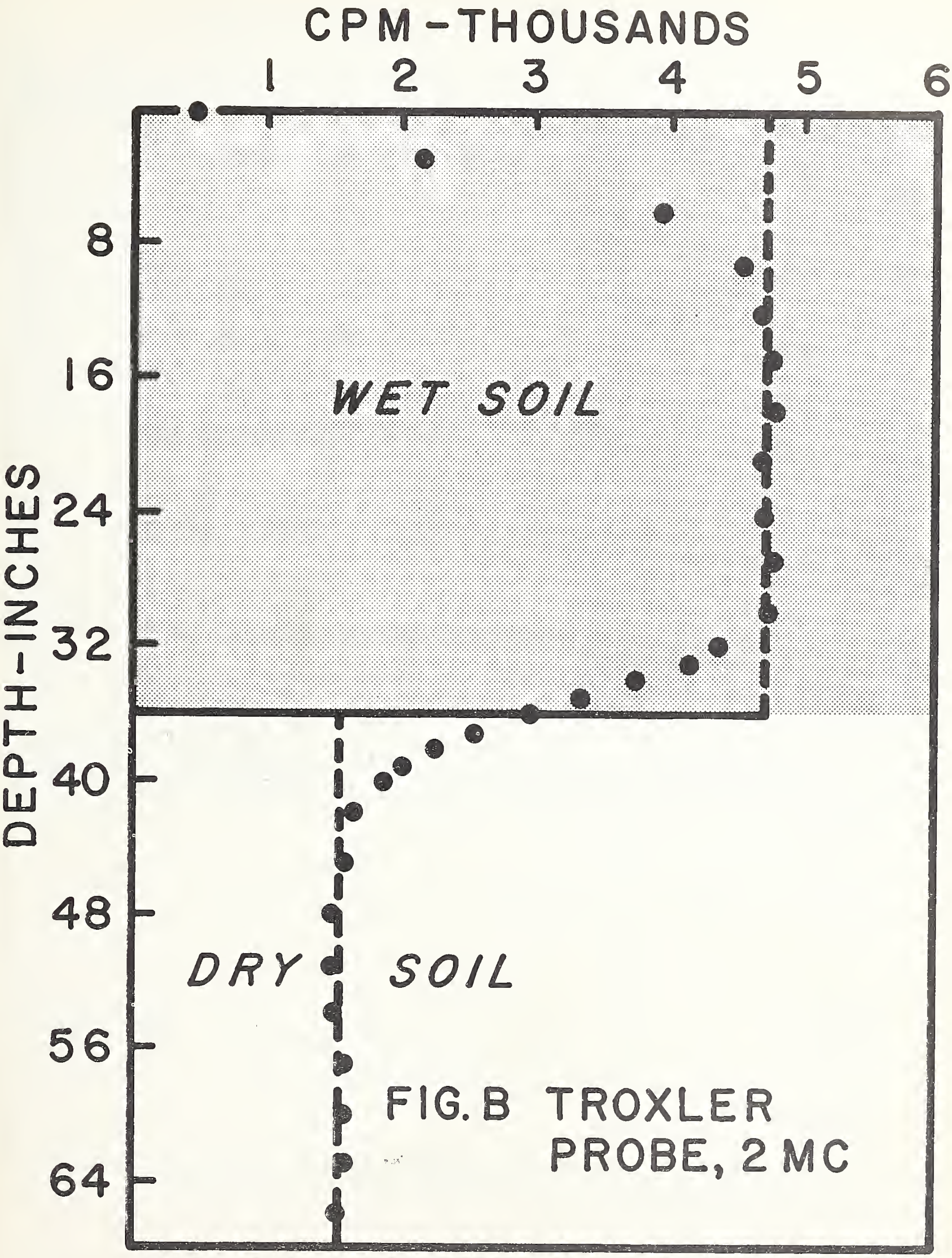


FIG. B TROXLER PROBE, 2 MC

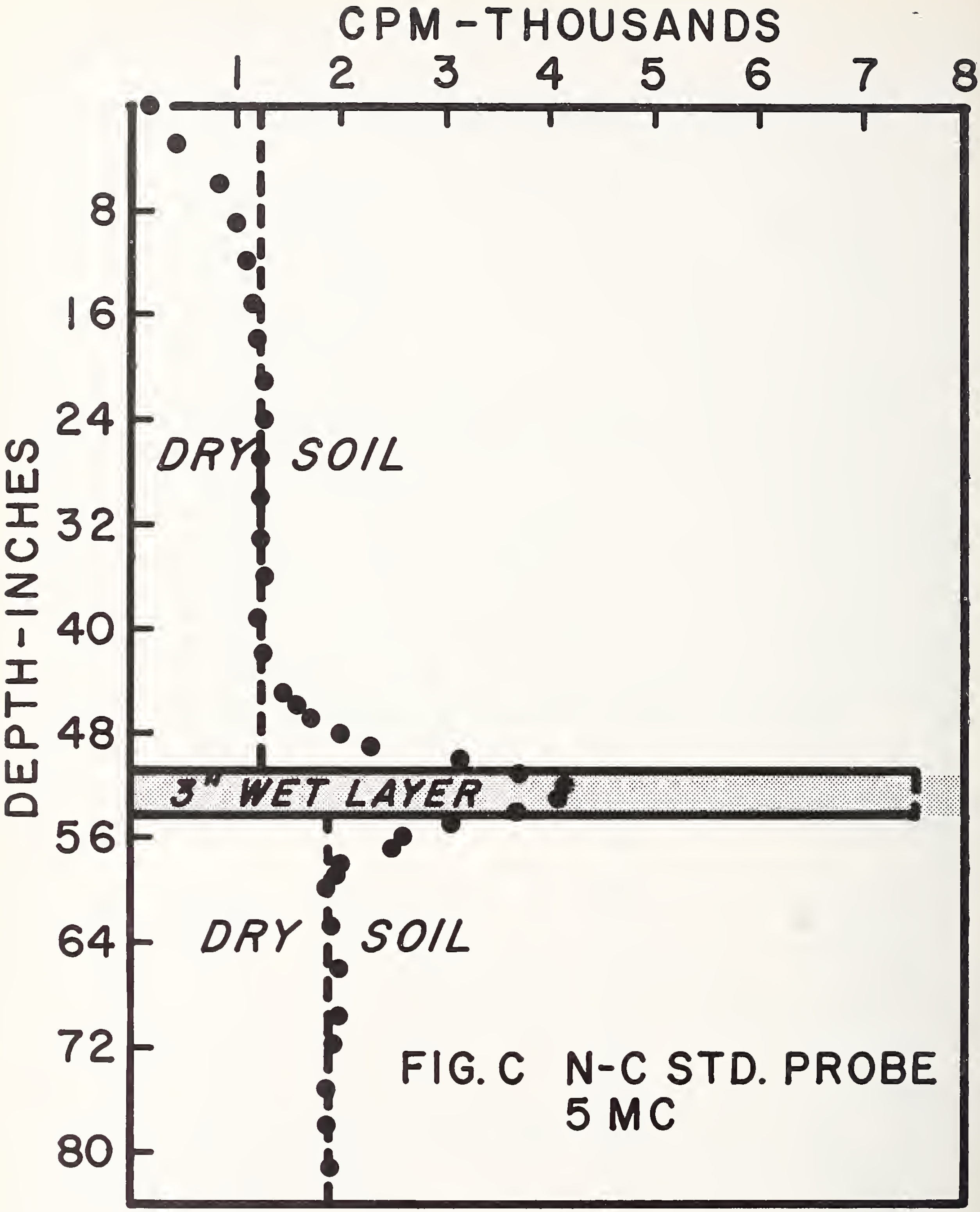
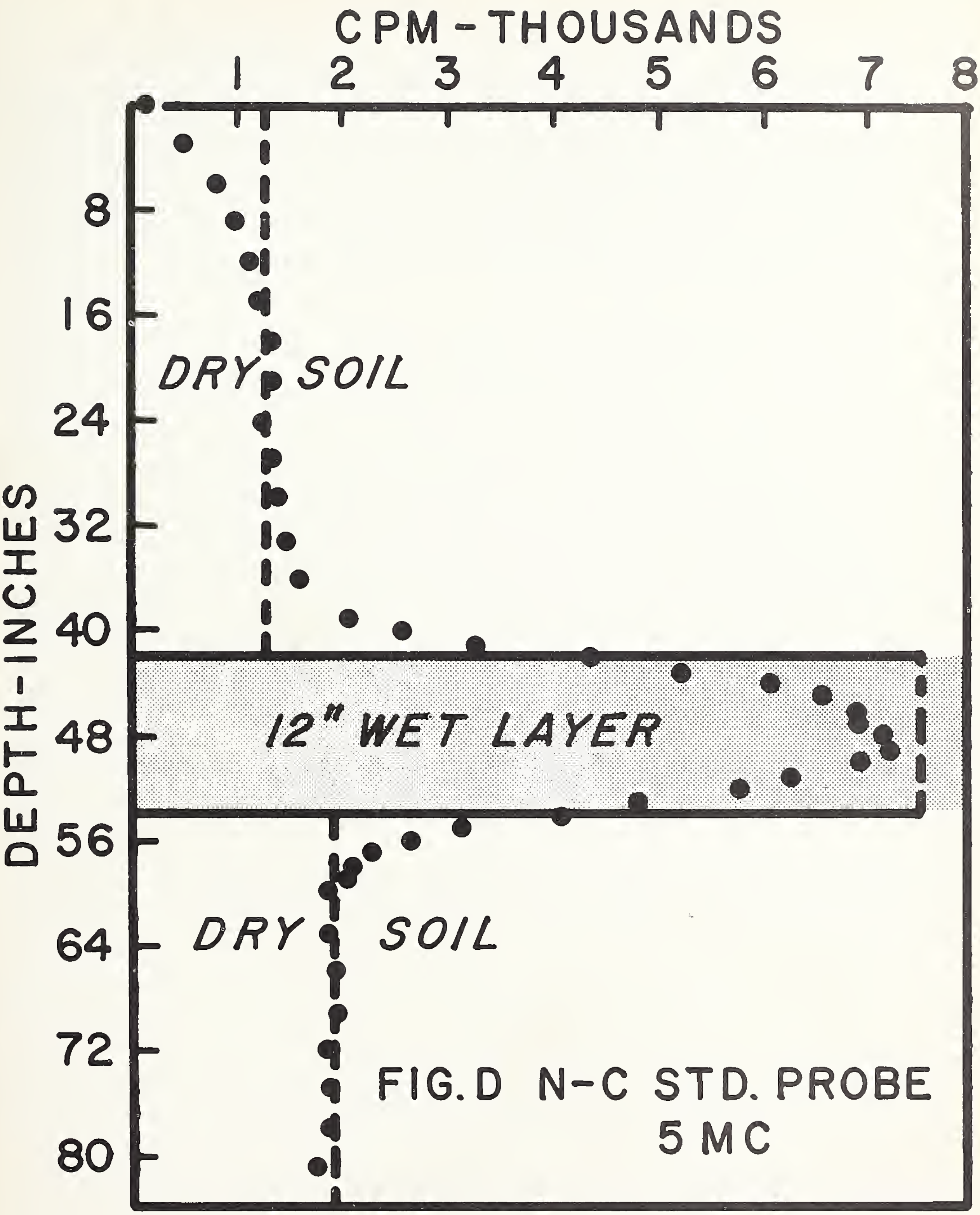


FIG. C N-C STD. PROBE
5 MC


CPM - THOUSANDS
1
2
3
4
5
6
7
8
DEPTH-INCHES
8
16
24
32
40
48
56
64
72
80
DRY SOIL
12" WET LAYER
DRY SOIL
FIG. D N-C STD. PROBE
5 MC

NITROGEN IMPROVES SOIL MOISTURE USE BY DRYLAND SPRING WHEAT

Truman Massee and F. H. Siddoway, St. Anthony.--Dryland wheat yield responses to nitrogen fertilization appear to be related to increased use of stored soil moisture. Growing season precipitation, although important to overall production, may not be the critical factor in determining nitrogen needs.

In 1955 an experiment was initiated to obtain information relative to the fertilizer requirements of dryland spring wheat. Continuous cropping was compared to the wheat-fallow system on Tetonia silt loam from a 13-inch rainfall area. Nitrogen fertilizer was applied to both cropping systems at rates of 0, 10, 20, 40, and 80 pounds of actual nitrogen per acre.

In 1956 and 1957 yield responses due to nitrogen applications were small, and yields from continuously cropped wheat were only slightly less than those from wheat grown after fallow. During these 2 years fallowing did not appreciably increase stored moisture found at seeding time. In 1958 growing season precipitation was much below average, but nitrogen yield responses were pronounced. Available stored moisture at seeding time totaled about 10.4 inches under both cropping systems this year. From the following table it can be seen that yield increases due to nitrogen were greatest on continuously cropped plots. Soil moisture utilization was greatest on the fallow plots. However, with both cropping systems nitrogen caused increases in soil moisture utilization. The 80-pound-per-acre rate on fallow caused some early season burning in the crop, and this effect is noted in the reduced moisture use. Stored soil moisture utilization was highly correlated ($r = 0.96$) with yield, with each additional inch of stored moisture used accounting for slightly more than a 7-bushel increase in yield. Increased soil moisture extraction resulting from nitrogen application occurred primarily in the second, third, and fourth foot of the soil profile. Nitrogen fertilization apparently increased the amount of rooting and, subsequently, greater moisture extraction at these depths.

Effects of nitrogen on wheat yields and soil moisture use

Rate of nitrogen per acre	Yield		Soil moisture use	
	Annual	Fallow	Annual	Fallow
	Bu. per acre	*Bu. per acre*	*Inches*	*Inches*
0	16.6	25.5	8.2	8.8
10	18.2	25.9	8.0	9.0
20	21.2	28.6	8.4	9.3
40	22.7	28.9	8.7	9.5
80	24.3	28.9	8.8	8.9

LSD .05 for yield = 2.1 bushels per acre.
LSD .05 for moisture use = 0.47 inches.

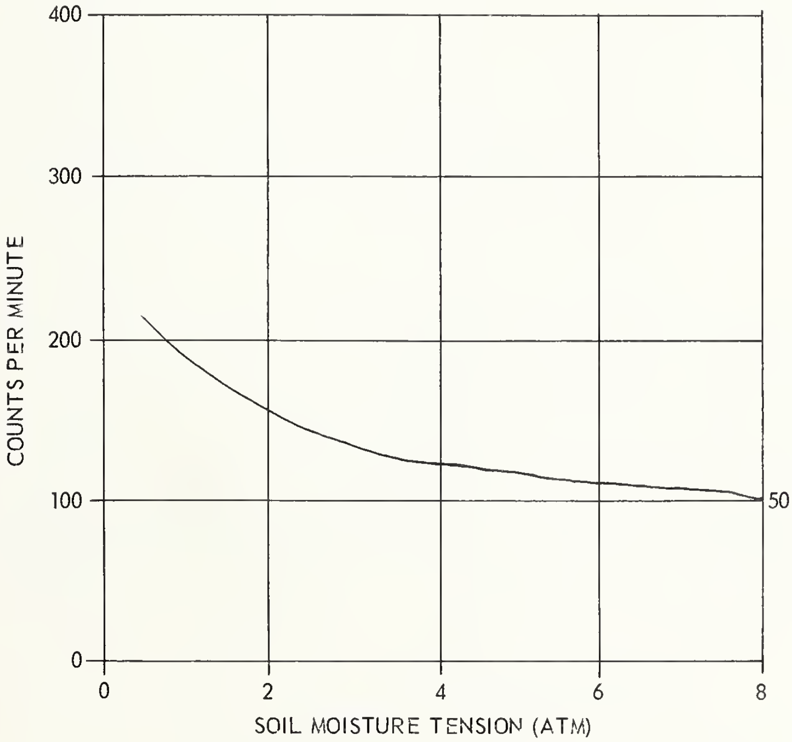
It appears that in years when stored moisture at seeding time is adequate, nitrogen fertilization may help offset poor precipitation conditions and markedly increase grain yields under continuous cropping. (V-D-2)

Illinois

WATER AND ION UPTAKE

D. B. Peters, Urbana.--The absorption of nutrient ions by plants from soils is strongly conditioned by the moisture tension and/or moisture content of the soil.

Recent experiments at Illinois and elsewhere have indicated that, where short-time experiments have been run, the absorption of phosphorus, calcium, magnesium, and rubidium is greatly reduced by decreased available moisture in the soil. An illustrative example, using rubidium as the experimental ion, is given below:



The exact cause for the reduction is not yet known. Research to date strongly suggests that the reduction may be due to rate limiting processes. The reduction in uptake can be partly offset by increased concentration of the ion species in question. (III-B)

Maryland

CROP REMOVAL AND SCRAPING DECONTAMINATES LAND

R. G. Menzel, Beltsville.--Highly effective removal of simulated radioactive fallout from land was achieved by scraping off topsoil, and some decontamination was achieved by removing a crop cover. Decontamination of land might be necessary for food production in areas of heavy fallout resulting from reactor accidents or from nuclear warfare.

Decontamination of bare soil was studied on Sassafras sandy loam and Elkton silt loam in rough plowed and seedbed conditions. Implements used for scraping were a bulldozer with an 8-foot blade, a road grader with a 7-foot blade, and two sizes of carrier-type scrapers. A 1-cubic yard scraper was used on the sandy loam and an 8-cubic yard scraper on the silt loam. In addition, decontamination by suction was attempted by using

a vacuum cleaner similar to a street sweeper without brushes. In all cases fallout contamination was simulated by applying dry glass beads, 28 μ mean diameter, with radioactive barium 140 adsorbed on their surfaces. The contamination was applied less than 2 days before decontamination.

All of the scraping methods removed more than 80 percent of the radioactive contamination (see table). On the silt loam somewhat more effective removal was achieved from seedbed than from rough plowed land. All of the scraping methods removed about 2 inches of soil, except the 8-cubic yard scraper removed about 7 inches. The vacuum cleaner removed less than half of the contamination, and appeared to be more effective on the sandy loam, which was somewhat drier than the silt loam and had essentially a single grain structure.

Percentage of simulated fallout (radioactive barium 140) removed from bare soil by scraping and vacuum cleaning, Beltsville, Md., 1959. (95 percent confidence interval)

Implement	Simulated fallout removed from		
	Elkton silt loam		Sassafras sandy loam
	Rough plowed	Seedbed	
	Percent	*Percent*	*Percent*
Bulldozer.........	92 - 99	95 - 100	92 - 99
Grader............	85 - 95	96 - 100	88 - 97
Scraper...........	97 - 100	97 - 100	91 - 99
Vacuum cleaner....	0 - 41	0 - 34	13 - 53

Decontamination of land in crops was studied by mowing stands of soybeans or Sudangrass which were about 12 inches tall. The ground cover was estimated to be 50 to 75 percent complete. Contamination was applied less than 24 hours before decontamination. Mowing and removing soybeans and Sudangrass removed 37 and 29 percent of the contamination, respectively. (III)

Nebraska

ORIENTATION PLANTING YIELDS LESS IN IRRIGATED CORN

O. W. Howe, Mitchell.--Results from an Illinois test showed that orientation planting of corn kernels compared with random planting increased yields from 3 to 23 bushels per acre. In a Nebraska test 30,000 corn plants per acre oriented in 30-inch rows yielded 5.8 bushels per acre less than when random planted.

The Illinois orientation planting system places the kernel with point down and flat sides with the row. Leaves of plants eventually develop almost perpendicular to the flat sides of the kernel and extend into spaces between rows. Plants shade the ground instead of neighboring plants in oriented planted corn. Thus, more sunlight falls on the leaf surfaces and much less reaches the soil. Evaporation is reduced, resulting in more water for crop production especially when ears are setting.

When optimum moisture is supplied by irrigation, it would appear that reducing evaporation from the soil would not be a factor in increasing yields, while more sunlit leaf surface, better CO_2, or light distribution might. In the Nebraska test the 40,000 plants per acre that emerged in orientation plots were thinned to 30,000 oriented plants. Corn in control plots, planted with a tractor mounted corn planter, also was thinned to

30,000 plants per acre. Frequent rain showers maintained ideal conditions for germination following the 1-week period during which all plots were planted. Grain yields were:

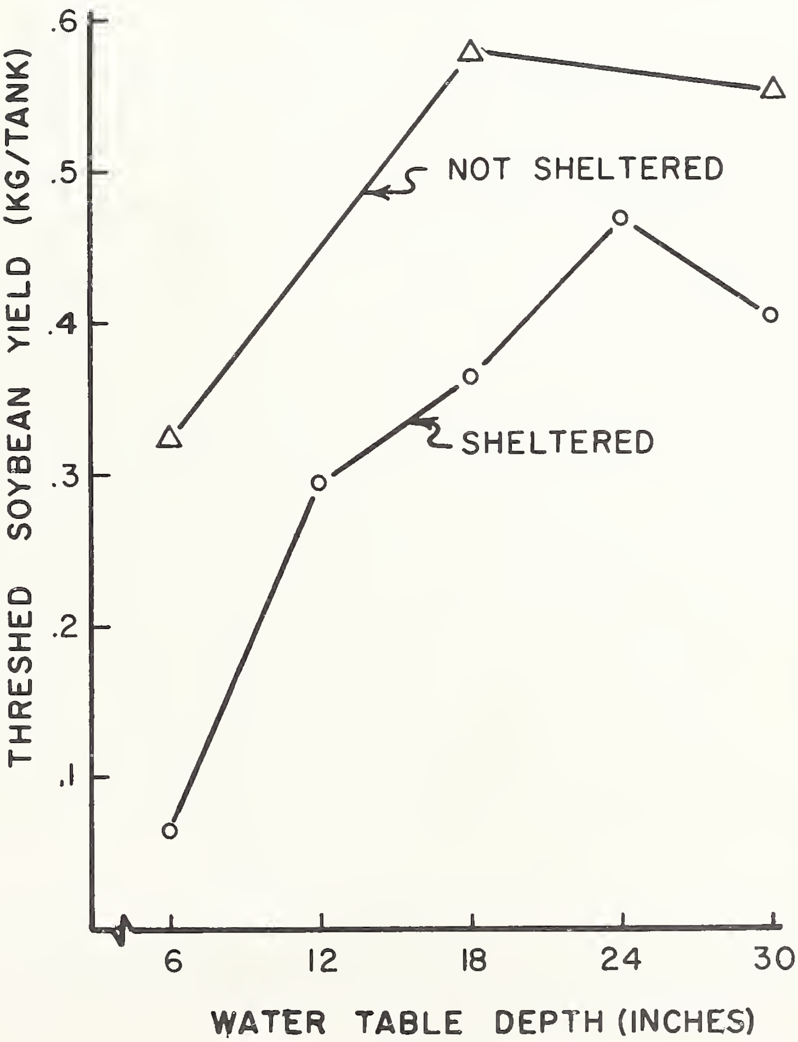
Replication number	Oriented planted	Random planted
	Bu. per acre	*Bu. per acre*
I	128.1	138.5
II	130.7	136.8
III	131.0	132.2
IV	142.4	147.7
Average	133.0	138.8

(II-A)

North Carolina

WATER TABLE AFFECTS YIELD OF SOYBEANS

R. E. Williamson and Jan van Shilfgaarde, Raleigh.--The optimum water table depth for field grown soybeans in a sandy loam topsoil was found to be in the range of 24 to 30 inches.



An experiment was designed to study the effects of water table height on crop performance. Soybeans were grown outdoors in 3' x 3- x 3-foot containers filled with a sandy loam topsoil. Most of these tanks were situated so that an automatically movable shelter kept off all rain; some were exposed to natural rainfall. In all tanks the water tables were maintained at constant depths varying from 6 to 30 inches below the surface from about 2 weeks after planting until harvest. Total water use was measured daily. Soybean yield data are shown in the figure on page 77.

Results show that the threshed bean yield and the yield of total plant material above ground were severely depressed with a 6-inch water table. Far better yields were obtained with the water table 12 or 18 inches below the surface, and best yields resulted with a water table at 24 to 30 inches (See figure.) It may be noted that the sheltered tanks (rain excluded) yielded less than the unsheltered ones, the difference being particularly striking for the 6-inch water tables. The yield difference at 6 inches was 450 percent, and at 18 inches it was 60 percent. The poor bean growth in the tanks with the 6-inch table was evident throughout the growing season. Attention is called to the reversal in yield response to water table depth noted here as compared to that observed in a growth chamber (Quart. Rpt. No. 21).

Evapotranspiration rates were roughly proportional to total growth. The rate for the tanks with 6-inch water tables was lowest; at 12 inches the rate was about double that at 6; and with lower water tables the rate was still higher. During August measured weekly rates varied from 0.4 to 2.0 centimeters per day.

One complication that arises in experiments such as these is the accumulation of salt in the upper layer of soils. Measurements made at the end of the season, in October, showed an average electrical conductivity of the saturation extract of 0.40 mmho/cm for the unsheltered tanks and of 4.25 for the sheltered tanks. The value 4.0 is often given as the danger level for sensitive crops. Some of the difference in yield between the sheltered and unsheltered tanks no doubt must be attributed to this salt accumulation. These findings, although still not conclusive, indicate the desirability of having some irrigation from the top during the growing season on tanks that are sheltered from rain. (II-B-5)

Texas

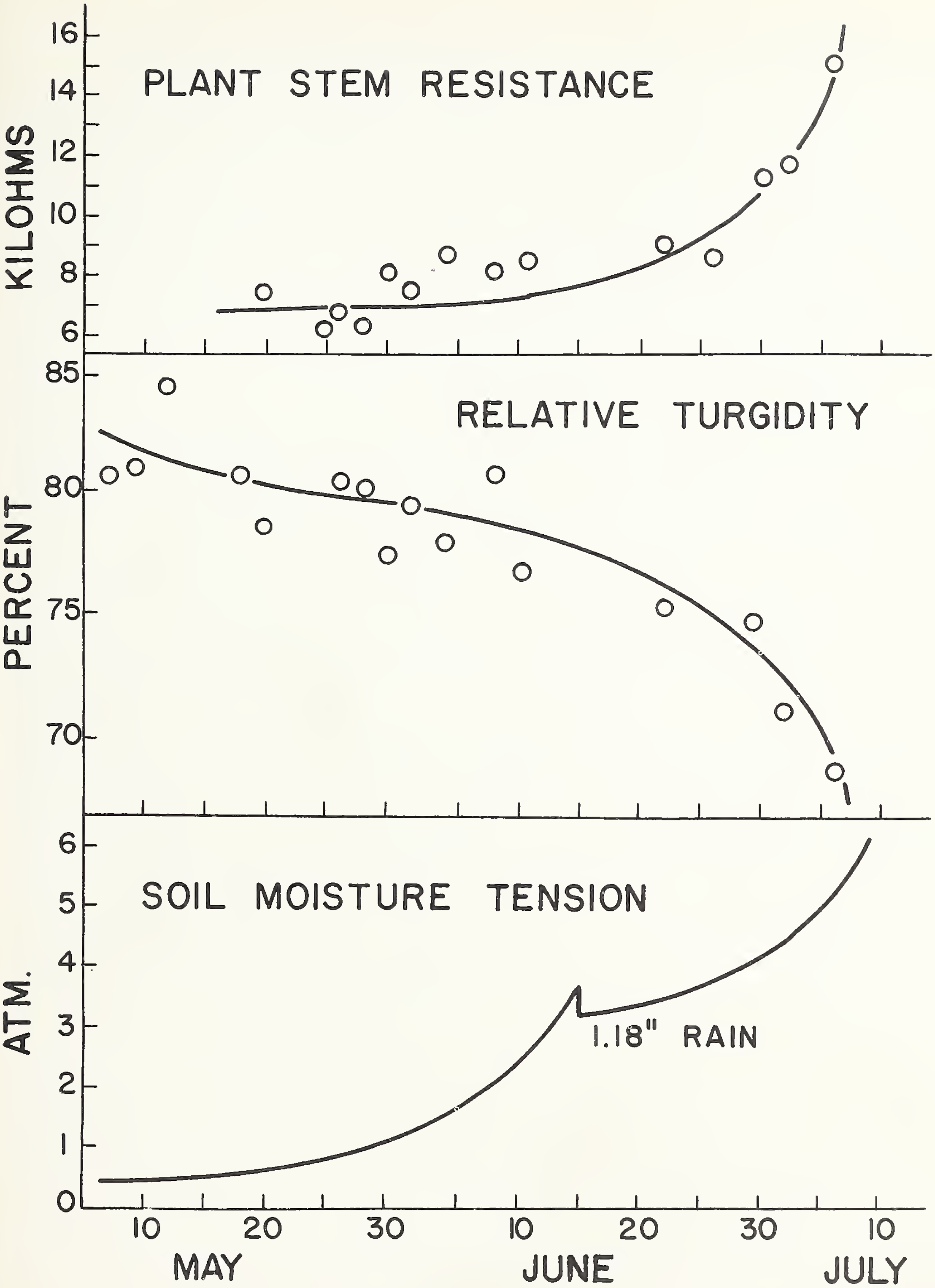
METHODS TESTED FOR MEASURING PLANT MOISTURE STRESS

L. N. Namken, Weslaco.--The plant stem resistance and relative turgidity methods show promise for following the internal moisture stress in cotton plants. The plant stem resistance method employs two electrodes mounted in a lucite holder. The electrodes are inserted into the cotton stem just above the node at ground level and the resistance between the electrodes read on an ohmmeter. This method is thought to give a measure of the hydration of the cellulose material in the cell walls of plant tissue.

The relative turgidity method expresses the water content of plant tissue under field conditions relative to what it is under optimum or saturated conditions. A sample consisting of 20 leaf discs is collected from randomly selected plants and weighed to determine the fresh weight (FW). The sample is floated on distilled water, under illumination, to allow full turgor pressure to be reached. After a predetermined time, the sample is removed from the water, blotted with filter paper, and reweighed to determine its full turgor weight (TW). The sample is then oven-dried and weighed to determine the dry weight (DW). Relative turgidity (RT) is calculated as follows:

$$RT = [(FW-DW)/(TW-DW)] \times 100$$

Field studies have established good relationships between the two methods and soil moisture tension. The accompanying figure shows the relationship among plant stem resistance, relative turgidity, and soil moisture tension during a growing season.



Soil moisture tension, relative turgidity, and plant stem resistance of cotton during the peak growing period. Weslaco, Tex., 1959.

The correlation coefficients between plant stem resistance and soil moisture tension, and between relative turgidity and soil moisture tension were highly significant (+0.890 and -0.920, respectively). The correlation coefficients were not so high in plots where the soil moisture tension was maintained at a fairly low level throughout the season.

The leaf discs and stem resistance measurements were taken at 6 a.m. and 1 p.m. However, only the data from the 1 p.m. sampling time are reported. The 6 a.m. sampling was evidently affected by heavy dews.

These data suggest the possible use of these methods for following the internal moisture stress in cotton plants and predicting when the cotton plants need water. Work is being continued on this study to determine the relationship between the atmospheric conditions at sampling time and the measurements obtained. This may possibly lead to the development of correction factors for varying atmospheric conditions at sampling time and more reliable data. (II-A-5)

Texas

STEERS GAINED WELL ON NATIVE GRASS

R. M. Smith and R. C. Henderson, Temple.--On 8 acres of native grass, yearling steers on scheduled spring grazing from April 15 to July 1 gave average gains of 90 pounds per acre from 1947 through 1951. When grazed in accordance with forage growth, the average for 1952 through 1959 was 122 pounds per acre. Average daily gain was 1.6 pounds by both systems of grazing, and native grass species have remained dominant throughout.

The accompanying table shows more detail of the annual grazing results during the last 8 years of grazing in accordance with growth. It is interesting to note that average

Grazing results for 8 acres of native grass[1] pasture, Blackland Experiment Station, Temple, Tex.[2]

Year	Grazing period[3]	Number animals average[4]	Animal days per acre	Acre gain	Daily gain	Railfall	
						Total	Jan. 1-June 30
				Pounds	*Pounds*	*Inches*	*Inches*
1952............	April 1 to July 1	5	60	142	2.34	31.1	19.2
1953............	March 23 to June 26	6	70	152	2.18	34.9	15.2
1954............	March 7 to June 30	6	91	122	1.35	13.8	7.4
1955............	February 27 to June 13	7	63	124	1.97	37.1	18.9
1956............	February 27 to June 13	7	67	85	1.27	16.4	9.6
1957............	March 11 to June 3	6	61	93	1.52	47.4	25.0
1958............	March 3 to July 29	7	105	134	1.27	33.8	19.6
1959............	April 14 to July 14 and July 17 to August 21	5 & 6	82	121	1.47	46.9	17.8
Average.......			74.8	121.6	1.62	32.7	15.3

[1] Mostly little bluestem, side-oats grama, Indiangrass and big bluestem, with Texas wintergrass, native forbs and other grasses.

[2] Soil types, Houston Black clay and Austin clay. Slopes, 0 to 5 percent, SCS capability units I-2, II-2, and II-2X.

[3] In 1952 grazing in accordance with growth was initiated. Before 1952 grazing was largely in accordance with schedule.

[4] The number of animals varied from 5 to 8 depending on pasture growth. Average initial weights were about 450 to 650 pounds.

daily gains varied from 1.27 pounds in 1958 to 2.34 in 1952. A part of this difference may be caused by inherent differences in gaining ability of the cattle. Quality and palatability differences in the growth for any 1 year also may be involved. Since stocking is always limited, there is never a shortage of forage growth for the cattle to obtain an abundant quantity. However, the quality and palatability may vary widely. In early spring the new green growth of cool-season species is so intermingled with mature growth from the previous season that the animals may be forced to eat some old dry grass of low palatability along with the new growth. As the season progresses the dominant species change. At first, Texas wintergrass is most evident, followed by side-oats grama and later by little bluestem, big bluestem, Indiangrass, Texas cupgrass, dropseed and other warm-season species.

Grazing in accordance with growth is based on individual judgment. The idea has been to try to utilize something like one-half of the total annual growth of major species during the time that the growth was active. The earliest grazing was started on February 27, 1956, when the growth was mainly Texas wintergrass plus anemone and some other early forbs. Usually the 8-acre area has been grazed with from 5 to 8 yearling steers weighing from 500 to 700 pounds. Adjustments in the stocking rate depend upon major variations of growth. The latest grazing practiced was in 1959 when late rains and a cool summer resulted in enough growth of major warm-season grasses that cattle were on the pasture until August 21. The final date of grazing has been as early as June 3. There is no clear, direct relation between rainfall and grazing return during the 8-year period, although it is obvious that moisture supply is a major factor influencing grass production in this area. With limited grazing as carried out, the effect of rainfall is less obvious than on intensely grazed or short grass areas.

The pasture involved in this study is about two-thirds Houston Black clay and one-third Austin clay. The beef cattle operation of which this pasture is a part includes 350 acres of land and about 100 head of steers, annually, with an annual economic analysis of the entire operation.

Basal diameter measurements of all species found in square-foot areas along established line-transects were carried out in December 1952 and again on October 9, 1959. On both dates the total ground cover was good. Total inches-diameters of major species were, as follows:

Grass Species	1952	1959
Little bluestem	30	14
Big bluestem	7	7
Side-oats grama	25	11
Indiangrass	21	15
Texas wintergrass	38	15
Texas cupgrass	17	50
Silver bluestem	4	4
Dropseed	17	14

Some of the differences noted may be influenced by individual judgment in making measurements or by date. Significance of the apparent increase in Texas cupgrass is uncertain. This species is not considered desirable, but other species and growth through the years seem to indicate pasture maintenance or improvement. (VI-A-1; VI-B-6)

Mississippi

HIGH RUNOFF FROM MODERATE STORM DURING FREEZING

Herbert B. Osborn, Oxford.--The storm on March 2, over the Pigeon Roost Creek Watershed in Mississippi, although moderate in amount and intensity, produced near record runoff under conditions of near freezing temperature and soil saturation. Snow was on the ground before, during, and after the storm. A freezing drizzle fell during the preceding night. The runoff-producing rain occurred on the morning of March 2.

Maximum intensities shown by any of the gages were less than 1 inch per hour, and total precipitation ranged from 1.30 inches to just under 2 inches. The maximum rainfall was along the ridge at the headwaters of the watershed. Most of the rain fell between 10 a.m. and 12 m., although light precipitation continued throughout the afternoon as combined rain, sleet, and snow. The air temperature was below 38° F. throughout the day, and the water temperature ranged from 34° to 38° F.

The lower part of Pigeon Roost Creek is a dredged, straightened channel, 10 miles long. Station 34, at the foot of the watershed, has a drainage area of 117 square miles. Station 17 is 7 miles above station 34 and has a drainage of 50.2 square miles. Cuffawa Creek with an 8-mile dredged channel is the main tributary. This creek joins Pigeon Roost 4 miles above station 34. Station 32 on Cuffawa Creek is 8 miles above station 34. It has a drainage of 31.3 square miles.

The stage at both stations 17 and 32 rose rapidly, peaked sharply, and fell rapidly. The peak stage at station 32 was 4200 c.f.s. at 12:45 p.m. The crest moving down Cuffawa reached station 34 on Pigeon Roost at 2:00 p.m. The total discharge was 4800 c.f.s. with a gage height of 8.75 feet. The peak stage at station 17 was 3300 c.f.s at 1:45 p.m. The peak from station 17 moved down the main channel as the flow from Cuffawa receded, and the gage height at station 34 was pushed up only 0.15 feet in the next 3 hours. The peak discharge was 5150 c.f.s. There was relatively little local flow or overflow during this peak.

Although the ground was frozen very lightly, the rainfall was at near freezing temperature and apparently caused low infiltration and high runoff from the basin. The result was a higher runoff from this moderate rainfall than would normally be expected.

Preliminary information has indicated that the percentage of sand in the measured sediment load was significantly higher than for warmer runoff water. (I-A-2)

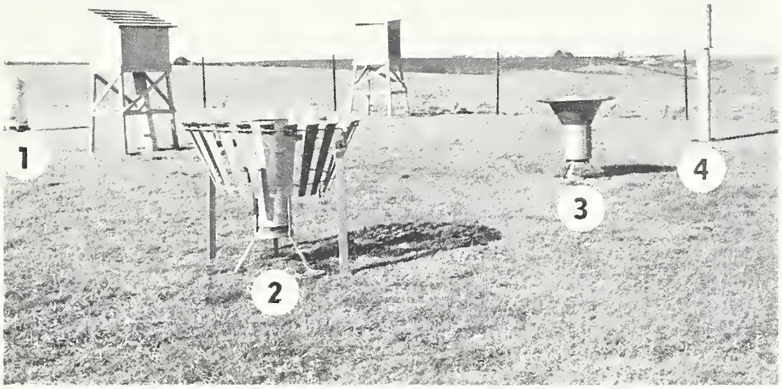
Nebraska

CATCHES OF RAIN BY SHIELDED AND UNSHIELDED GAGES DIFFER

John A. Allis, Hastings.--An analysis of 14 years of continuous rainfall records has shown that the annual catch of a shielded rain gage is significantly different from that of an unshielded gage. The gages tested at the field station near Rosemont, Nebr., included an unshielded standard gage used as a control and installed in accordance with specifications of the Weather Bureau; a standard gage with an Adler shield; and a standard gage with a Nipher shield. A standard gage mounted on a post so as to be above the ground drifting of snow and a recording gage were also included in the tests.

The least squares equations for the annual catch of the several gages, referenced to the standard gage are:

$S = 1.03\,A - 1.83$ for the Adler shielded gage (A)
$S = 0.996\,N - 1.53$ for the Nipher shielded gage (N)
$S = 1.00\,P + 0.37$ for the gage on a post (P)
$S = 0.998\,R + 0.28$ for the recording gage (R)



Meteorological Station, Rosemont, Nebr., May 6 to November 2, 1959: (1) Recording rain gage, (2) Adler shielded standard rain gage, (3) Nipher shielded standard rain gage, and (4) Standard rain gage on post.

The differences indicated in the equations for the shielded gages are significant to the 0.1-percent level; for the gage on the post to the 2.5-percent level; and for the recording gage to the 5-percent level.

In an average year of 24 inches of precipitation as measured in the standard rain gage, one could expect a catch of 25.08 inches in the Adler shielded gage; 25.63 inches in the Nipher shielded gage; 23.63 inches in the gage on a post; and 23.77 inches in the recording gage. For individual years, the catch in the shielded rain gages was always greater than the unshielded standard gage, ranging up to 3.25 inches for the Nipher shielded gage. (I-A-2)

Ohio

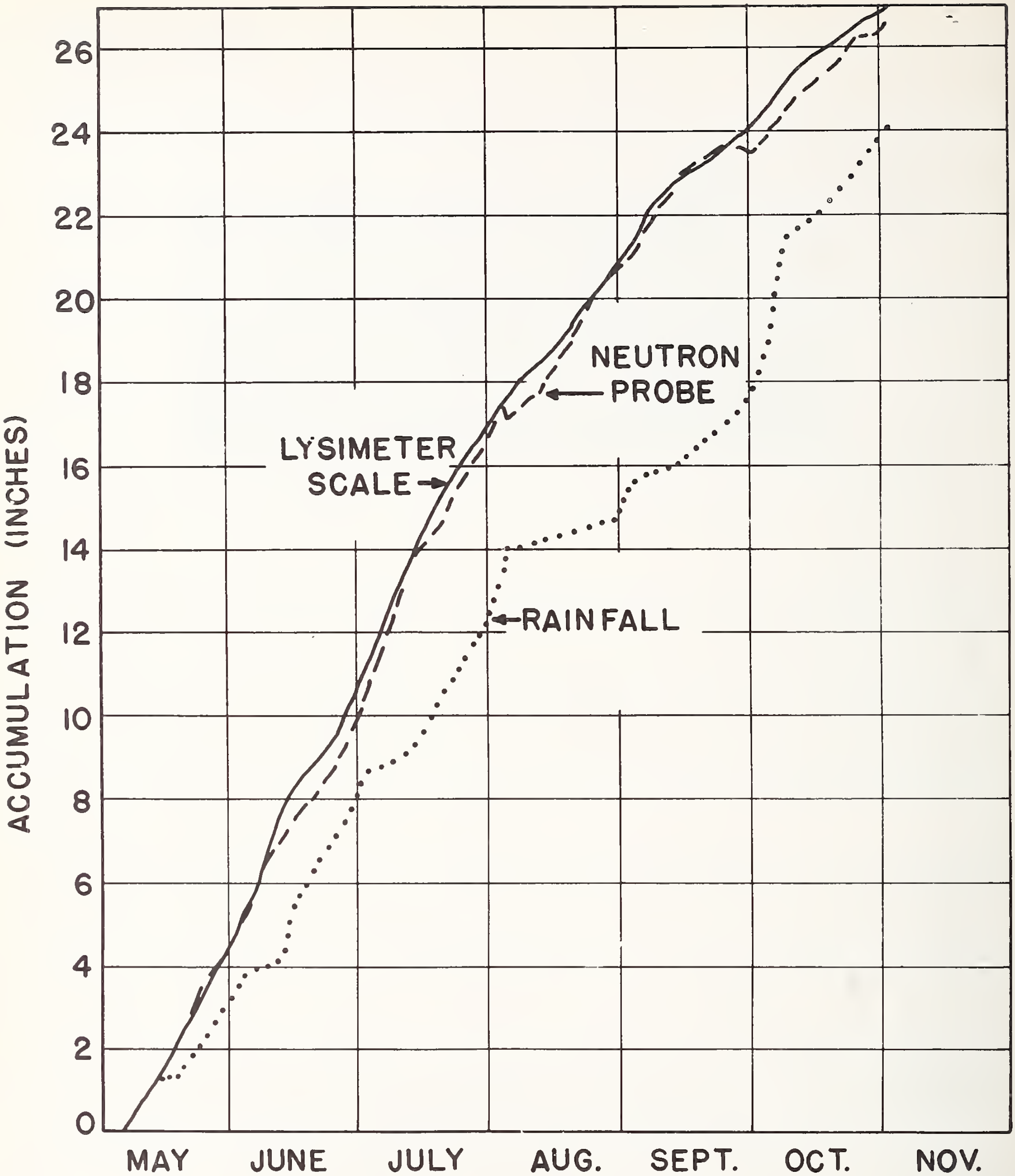
NUCLEAR MOISTURE PROBE CHECKS WITH WEIGHING LYSIMETERS

F. R. Dreibelbis and J. L. McGuinness, Coshocton.--The weighing feature of the Coshocton monolith lysimeters have provided a means of evaluating the water budget by the following equation:

$$ET = P - Q - G \pm \Delta M$$

where ET is evapotranspiration, P is precipitation, Q is surface runoff, G is percolation, and ΔM is the change in soil moisture of the profile. Concurrent lysimeter weight records and neutron probe readings furnished a basis for determining the reliability of the neutron probe for estimating (ET) consumptive use of soil moisture when percolation is known.

The accompanying figure shows a cumulative plotting of the consumptive use data for the growing season May 6 to November 2, 1959. Rainfall as measured by the lysimeter is shown on this graph. The soil type is Keene silt loam in first-year meadow of a 4-year rotation of corn, wheat, meadow, and meadow. Values of evapotranspiration as determined by the lysimeter scales and those determined independently by the neutron probe were almost identical throughout the season. At the end of the 6-month period accumulative values were only 0.31 inch apart. (I-B-6)



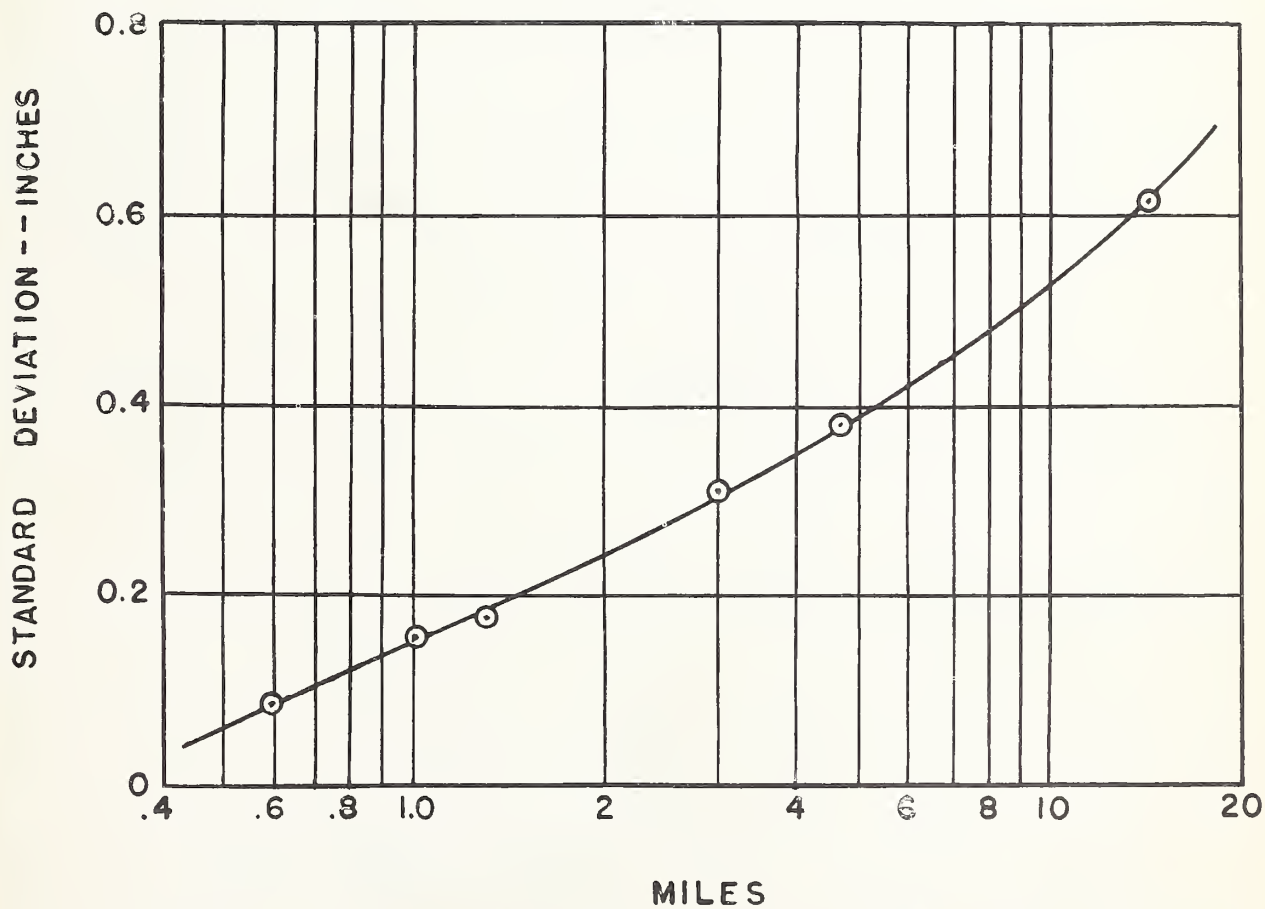
Evapotranspiration as measured by weighing lysimeters and as measured by the neutron probe, Coshocton, Ohio, May 6 to November 2, 1959

EXPECTED DIFFERENCES BETWEEN WATERSHED AND POINT RAINFALL

Walter G. Knisel, Jr., Riesel.--An analysis of watershed and point storm rainfall indicates the deviation that can be expected in estimating watershed rainfall for a 1,110-acre area from single gages at various distances from the center of the watershed. The data from 215 storm events greater than 0.25 inch were used in the study.

In the analysis, watershed rainfall was determined by the Thiessen weighting of three raingages within the 1,110-acre watershed. Then the watershed rainfall was related to point rainfall at each of six locations that were various distances from the center of the watershed. The standard deviation was computed for each of the six relationships.

The figure shows the standard deviations related to distance from the watershed center. For example, if one were to estimate rainfall for the watershed from point rainfall 2 miles from the watershed center the estimate for about two-thirds of the cases would fall within ± 0.22 inch of the true value of the watershed rainfall and in practically all cases would fall within ± 0.66 inch of the true value. (I-A-1)



DISTANCE OF POINT RAINGAGE FROM WATERSHED CENTER
WATERSHED "D" RIESEL, TEXAS

MOST OF RUNOFF PRODUCED IN FEW YEARS

Ralph W. Baird, Riesel.--A comparatively few years produce a major part of the runoff from the experimental watersheds near Riesel. From a typical watershed of 176-acre area and mixed land use, almost 80 percent of the runoff came in 8 years of the 22-year period of record. (See table.)

Runoff from various annual rainfall amounts

	Annual rainfall greater than--						
	20"	25"	30"	35"	40"	45"	50"
No. of years	21	16	12	8	7	3	2
Percent of total runoff	98.8	94.6	85.0	76.6	70.2	40.0	30.6

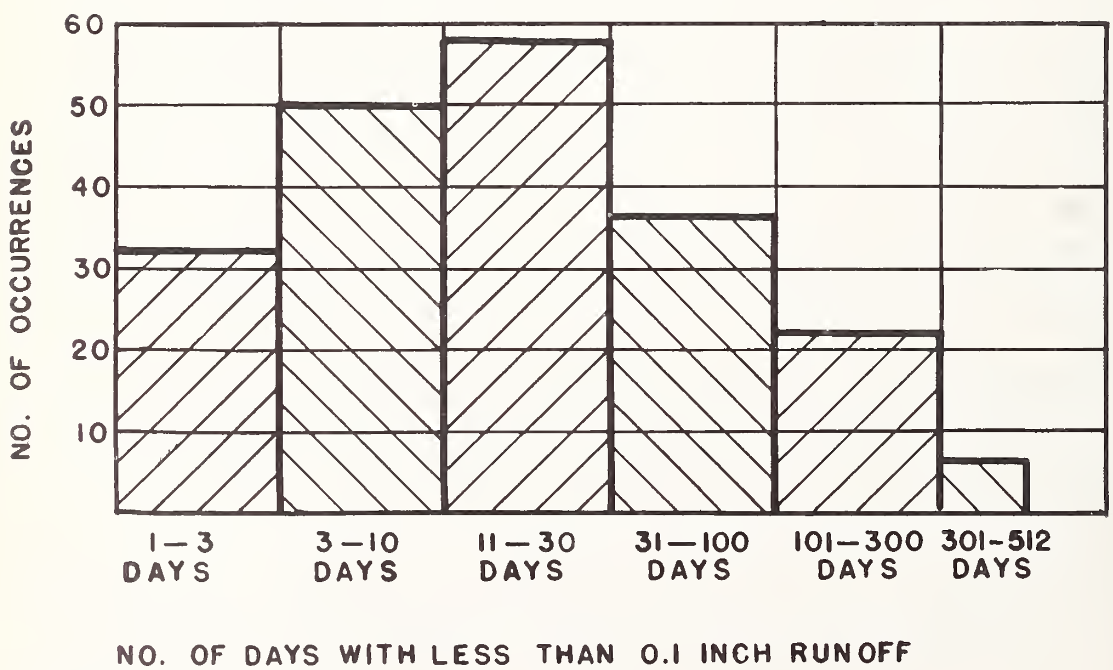
In other words, about 80 percent of the water was produced in about 35 percent of the years in the period, and the remaining 20 percent in about 65 percent of the period. These 8 years of high runoff were the years in which rainfall was greater than the 34-inch average. Six of the 8 years were in one consecutive 7-year period--there being one below normal year included midway in the 7-year period.

Examining the 22-year record of this watershed from the point of view of number and length of "dry" periods, as in the figure, there were 25 periods of 100 or more days when the total flow was less than 0.1 inch. One of these periods extended for 512 days, and after a lapse of 1 day with 0.38 inch of runoff, continued for another 135 days.

PERIODS OF DIFFERENT DURATIONS WITH LESS THAN 0.1 INCH RUNOFF

WATERSHED W-1 176 ACRES

22 JUNE 1937 — 22 JUNE 1959



These data indicate the need for substantial carryover storage in small water supply structures; the wide variability in runoff emphasizes the need for long-term records to characterize the runoff potential of the watersheds. (I-A-1)

SEDIMENTATION

Mississippi

GULLY EROSION STUDIES SHOW RATES OF SEDIMENTATION

Russell Woodburn, Oxford.--In the fall of 1955 seven gullies were selected in Lafayette County, five in Carroll County, and six in Tallahatchie County for erosion rates studies. Permanent ranges were established on each of the 18 gullies for determination of the amount of sediment removed from the bare surfaces of the gully and deposited behind a small earth dam constructed to form a sediment pool.

A resurvey was made of all gullies in the fall of 1957, and the volume of sediment in each small gully storage reservoir was computed.

In October 1959 another resurvey was made of all of the gullies, and sediment accretion in each pool (1957-59) was computed. The amount of sediment volume in each storage pool was related to the net bare erosion surface of the gully and converted into equivalent vertical inches of soil removed per year. This erosion rate for each gully is shown for the 1955-57 period and for the 1957-59 period, along with the 1955-59 average rate. (See table.)

Gully erosion rates from bare gully surface for three gully groups, 1955-59

Gully No.	Treatment	Erosion rate per year		
		Oct. 1955 - Oct. 1957	Oct. 1957 - Oct. 1959	Oct. 1955 - Oct. 1959
		Inches	*Inches*	*Inches*
			LAFAYETTE COUNTY	
1................	Kudzu-Mulch	1.236	1.035	1.135
2................	Mulch	0.724	1.022	0.873
3................	None	1.374	2.908	2.141
4................	Trees	0.804	0.765	0.785
5................	Trees-Mulch	0.600	0.509	0.554
6[1]...............	....do.....	0.720	0.317	0.518
7[1]...............	Grass-Brush dams Kudzu	3.660	1.640	2.650
			CARROLL COUNTY	
1................	Mulch	3.130	1.881	2.505
2................	Trees	[2] 6.650	2.125	4.388
3................	None	[2] 9.200	5.453	7.327
4................	Trees-Mulch	2.340	1.845	2.092
5................	....do.....	[2] 1.760	0.852	1.306
	Grass-Brush dams			
			TALLAHATCHIE COUNTY	
1................	Mulch	2.982	1.736	2.359
2................	Trees-Mulch	1.878	1.232	1.555
3................	....do.....	[2] 1.278	0.606	0.942
	Grass-Brush dams			
4................	None	[2] 4.644	2.338	3.491
5................	Trees	[2] 3.948	0.985	2.466
6[1]...............	None	[2] 5.340	2.029	3.685

[1] A higher sand content than the other gullies.
[2] 70 percent or more of sediment pool volume at time of 1957 resurvey, October.

The erosion rates were materially lower for the second 2-year period.

When the 4-year average annual erosion rates are considered, it is obvious that a wide variation exists from gully to gully within some county groups and to a much greater extent from one county group to another. It is also significant that the most intensive protective treatment, that is trees, mulch, grass and brush dams, results in the lowest erosion rate for each group in the county. The gully without treatment in each group was the highest erosion producer for that group except for number 7, Lafayette County. (See table.) This gully had a higher sand content than the others of its group which explains its very high sediment production rate.

When all of the gullies in the three groups are averaged together (with the exception of No. 6, Lafayette, No. 5, Carroll, and No. 3, Tallahatchie), the 4-year average erosion rate is 2.53 inches per year. (I-B-2a)

Mississippi

RESURVEYS OF RESERVOIRS SHOW RATES OF SEDIMENTATION

Russell Woodburn, Oxford.--A resurvey was made in August 1959 of the W. W. Murphy and the Andrew Smith reservoirs. These are small desilting reservoirs in upper Pigeon Roost Creek in Marshall County. These ponds were first surveyed at the time of construction, November 1953, and resurveyed in 1956.

The findings of the two resurveys are shown in the table. A rather sharp reduction in sediment catchment appears during the second 3-year period.

When sediment volume is converted into equivalent watershed erosion rate, it varies from 0.07 to 0.10 inch per year over the 6-year period. These rates are appreciably lower than the rate of 0.12 inch per year reported in 1958 for the "powerline" reservoir in Lafayette County for a 5-year period. (I-B-3)

TABLE 1.--Summary of reservoir sedimentation surveys--Pigeon Roost Creek Watershed

Period	Reservoir	Below inlet	Sediment above inlet	Total	Sediment pool volume lost	Equivalent watershed erosion rate per year
		Acres-Feet	*Acres-Feet*	*Acres-Feet*	*Percent*	*Inches*
1953-56	W. W. Murphy[1]	2.96	1.23	4.19	13.05	0.15
1956-59........		1.88	.63	2.51	8.30	.07
1953-59........		4.84	1.86	6.70	21.35	.105
1953-56........	Andrew Smith[2]	3.89	.75	4.64	17.1	.11
1956-59........		1.06	.97	2.03	4.7	.04
1953-59........		4.95	1.72	6.67	21.8	.0665

[1] Drainage area--133 acres-Sediment pool volume--22.7 ac-ft. (below inlet)
[2] Drainage area--209 acres-Sediment pool volume--22.7 ac-ft. (below inlet)

Nebraska

ELEVATION OF SPILLWAY DETERMINED BY NEW FORMULA

H. G. Heinemann, Lincoln.--The distribution of sediment that will accumulate in a proposed floodwater retarding reservoir has long been a problem in planning and design. If one knew how the sediment would be distributed, he could better determine the minimum elevation of the principal spillway.

A study was recently completed of the sediment distribution in 23 small conservation reservoirs in the Missouri Basin loess hills. This is an area of western Iowa, eastern Nebraska, and northwestern Missouri. The characteristics of these reservoirs are similar to those of floodwater retarding structures being built by the Soil Conservation Service (P.L. 566), and the findings are considered directly applicable. Considerable data were obtained on these small ponds and reservoirs, and Stage-Capacity, Capacity Replaced by Sediment, and Sediment Distribution curves were drawn for each structure.

After making numerous graphical analyses, the multiple regression approach was used to develop a procedure whereby the elevation can be determined to which sediment will accumulate immediately upstream from a small floodwater retarding structure. Assuming that the total initial reservoir capacity has been established for a proposed structure and that the sediment deposition quantities and specific weight of sediment for a given design period has been determined, the following equation can be used:

$$Y = 22.6 + 0.886D - 81.2n - 0.175C + 0.494w$$

where Y = percent of original reservoir depth filled with sediment

D = total original storage depletion in percent

n = slope of line on logarithmic paper, where the original reservoir depths (ordinates) are plotted versus original reservoir capacities (abscissas)

C = total remaining storage capacity

w = sediment sample volume weight

From this equation the percent of original reservoir depth can be readily established below which the initial capacity will be completely filled with sediment. This is the elevation at which sediment will accumulate immediately upstream from the dam and is, therefore, a guide to the minimum elevation for the principal spillway.

It should be emphasized that this first study and the resulting material applies to small floodwater retarding structures in the Missouri Basin loess hills only. The complete study and results will be given in a forthcoming ARS-41 Series Report. Additional analyses are planned or under way to study relationships applicable in other areas. (I-B-4b)

Texas

FLOCCULENTS PRECIPITATE PLAYA LAKE SUSPENSIONS

Wayne Clyma and M. E. Jensen, Bushland.--Thousands of shallow (playa) lakes collect rainfall runoff in the High Plains of Texas. Most of this water evaporates unless it is used for irrigation or for recharging underground water supplies. Playa-lake water may contain from 0.5 to 2.5 tons of sediments, largely clay, per acre-foot of water. By using a flocculent, Sepran AP-30, in a recharge test conducted in April 1959 the amount of silt and clay entering a recharge well was reduced 49 percent. The amount of water recharged was 1,137,300 gallons in a 24-hour period. Before treatment this water contained 0.37 ton of sediments per acre-foot of water. The quantity of silt and clay removed from the well during the 1-hour pumping cycle following recharge was 2.4 percent of the amount that entered the well. The combination of the flocculent and pumping cycle resulted in 50.2 percent less sediments entering the well compared to 7 to 10 percent removed using the 1-hour pumping cycle alone. (I-B-6)

Minnesota

MOVIE MADE OF FLOW THROUGH DRAIN TILE JUNCTIONS

Fred W. Blaisdell and P. W. Manson, Minneapolis.--"Energy Losses at Converging Pipe Junctions" is a 16 mm., animated, color, 24-minute movie, with sound track, of flows through drain tile junctions. Particular emphasis is given to agricultural drain tile junctions flowing full of water. Techniques of laying tile in the field and the laboratory tests and significant findings are presented pictorially with an oral account on the sound track. Transparent pipes are used, and the water in the lateral is colored to show how it joins the water in the main.

This movie is available from Professor Philip W. Manson, Department of Agricultural Engineering, University of Minnesota, St. Paul 1, Minn., or from Agricultural Research Service, St. Anthony Falls Hydraulic Laboratory, Third Avenue SE at Mississippi River, Minneapolis 14, Minn. (II-B-2b)

Minnesota

TESTS ON HEAD-DISCHARGE CURVE OF TWO-WAY DROP INLET

Fred S. Blaisdell and Charles A. Donnelly, Minneapolis.--The two-way drop inlet studied has a width equal to the pipe diameter and is 2 to 10 pipe diameters in length. Water enters the drop inlet over the two long edges. The ends of the crest are blocked off by walls which support a flat anti-vortex plate. The anti-vortex plate and end walls support a trash guard.

Tests were made to determine the performance and capacity of the spillway with various heights of the anti-vortex plate and various lengths of plate overhang outside the drop inlet. These tests indicated that if the plate overhang is too small, vortexes will form and let air into the drop inlet. The minimum length of overhang for satisfactory performance varies with the height of the plate above the drop inlet crest. Criteria for determining the minimum permissible plate height and overhang to prevent vortexes have not yet been developed.

The head-discharge curve for the spillway is in three parts: (1) Weir flow controls the head-discharge relationship at low heads and discharges. (2) Pipe flow controls the head-discharge relationship at the highest heads and discharges. (3) The plate height and overhang control the head-discharge relationship for intermediate heads and discharges. Air is carried through the spillway during periods of plate control.

The plate control head-discharge relationship as now defined is

$$\frac{H}{B} = \frac{Z_p}{B} - 0.1 + 0.1 \log \frac{L_o}{B} + \left(0.1 - 0.05 \frac{L_o}{B}\right) \quad \frac{Q}{2LB^{3/2}}$$

The quantity within the parentheses becomes zero for values of L_o/B equal to or greater than 2.

In the equation, H is the head on the spillway crest in feet, B is the width of the drop inlet in feet, Z_p is the distance between the spillway crest and the under side of the plate in feet, L_o is the length of overhang of the plate from the outside of the drop inlet in feet, and Q is the flow in cubic feet per second. This equation was developed from drop inlets 2 and 10 pipe diameters long by 1 pipe diameter wide. Crest thicknesses, 1/9 and 4/9 pipe diameter, were used for the shorter drop inlet. Tests are planned to check this equation for other drop inlet lengths. (I-C-1)

PAPERS AND PUBLICATIONS

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